edexcel

INTERNATIONAL ADVANCED LEVEL

CHEMISTRY

AS EXEMPLARS WITH COMMENTARIES

Pearson Edexcel International Advanced Subsidiary in Chemistry (XCH11)
First teaching September 2018
First examination from January 2019
First certification from August 2019

Pearson

Introduction

This booklet has been produced to support chemistry teachers delivering the new International Advanced Level Chemistry specification for first teaching in September 2018 and first assessment in January 2019.

This booklet looks at questions from the Sample Assessment Materials. It shows real student responses to these questions, and indicates how the examining team will follow the mark schemes to demonstrate how students would be awarded marks in these questions.

We have selected some responses to 5 questions, with mark schemes, from the sample assessment materials. A range of student responses with accompanying examiner commentaries on how the mark scheme has been applied then follow.

Other teaching and learning materials for this specification are available on the IAL Chemistry subject page here.

Question 1 – Exemplar 1

1 This question is about bromine.

(a) Complete the electronic configuration for a bromine atom, using the s, p, d notation.

[Ar] $3d^{10}\ 4s^2\ 4p^5$

(b) Bromine exists as two isotopes with mass numbers 79 and 81.

(i) Complete the table to show the numbers of subatomic particles in a ^{79}Br atom and a $^{81}Br^-$ ion.

Species	Protons	Neutrons	Electrons
^{79}Br	44	35	44
$^{81}Br^-$	46	35	47

(ii) A sample of bromine contained equal amounts of the two isotopes.

Complete the mass spectrum to show the peaks you would expect for Br_2^+ from this sample of bromine gas.

$Br^{79}Br^{81}$

$Br^{81}Br^{81}$

$Br^{79}Br^{79}$

(iii) Calculate the number of bromine molecules in 2.00 g of Br_2.

[Avogadro constant = $6.02 \times 10^{23}\ mol^{-1}$]

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

$= \frac{2.00}{159.8}$ = $0.0125 \times 6.02 \times 10^{23}$

Number of molecules = 7.525×10^{21}

(c) A sample of bromine gas occupied $200\ cm^3$ at a temperature of 77 °C and a pressure of 1.51×10^5 Pa.

Calculate, using the ideal gas equation, the amount in moles of bromine molecules in this sample.

[$pV = nRT$ $R = 8.31\ J\ mol^{-1}\ K^{-1}$]

$(1\ cm)^3 = (10^{-3}\ m)^3 = 10^{-9}\ m^3$

$273 + 77 = 350$

$pV = nRT$

$n = \frac{pV}{RT}$

$n = \frac{1.51 \times 10^5\ Pa \times 200 \times 10^{-9}\ m^3}{8.31\ J\ mol^{-1}\ K^{-1} \times (273 + 77)}$

Amount of bromine molecules = 1.038×10^{-5} mol

Examiner commentary
Question 1 Exemplar 1

(a) correct
(b)(i) 0 marks awarded as protons and neutrons and electrons incorrect in both rows.
(b)(ii) and (iii) correct.
(c) 3 marks awarded as calculation correctly processed with 1 error, the incorrect conversion of cm^3 to m^3.

QUESTION 1 – Exemplar 2

1 This question is about bromine.

(a) Complete the electronic configuration for a bromine atom, using the s, p, d notation. [1]

[Ar] $4s^2 3d^{10} 4p^5$

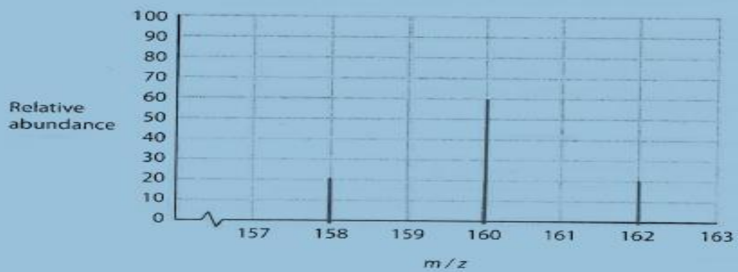
(b) Bromine exists as two isotopes with mass numbers 79 and 81.

(i) Complete the table to show the numbers of subatomic particles in a ^{79}Br atom and a $^{81}Br^-$ ion. [2]

Species	Protons	Neutrons	Electrons
^{79}Br	35	44	35
$^{81}Br^-$	35	46	36

(ii) A sample of bromine contained equal amounts of the two isotopes.

Complete the mass spectrum to show the peaks you would expect for Br_2^+ from this sample of bromine gas. [2]



(iii) Calculate the number of bromine molecules in 2.00 g of Br_2.
[Avogadro constant = 6.02×10^{23} mol^{-1}] [2]

$n = \frac{m}{Mr}$ $n = \frac{2}{79.9}$

$n = 0.02503$ mol

molecules = $(6.02 \times 10^{23}) \times 0.02503$ → 1.507×10^{22} molecules

Number of molecules = 1.507×10^{22}

(c) A sample of bromine gas occupied 200 cm^3 at a temperature of 77 °C and a pressure of 1.51×10^5 Pa.

Calculate, using the ideal gas equation, the amount in moles of bromine molecules in this sample.

[$pV = nRT$ $R = 8.31$ J mol^{-1} K^{-1}] [4]

~~$(1.51 \times 10^5) \times 200 = n \times 8.31 \times 77$~~

$(1.51 \times 10^5) \times (2 \times 10^{-4}) = n \times 8.31 \times 350$ ~~n = 47197 mol~~ ~~0.047197 mol~~

~~n = 0.01854~~

$n = 0.0104$ moles ~~6.02~~ ~~$6.02 \times 10^{23} \times 0.047197$~~ ~~$= 2.84 \times 10^{22}$~~

$= (6.02 \times 10^{23}) \times 0.0104$

$= 6.25 \times 10^{21}$

Amount of bromine molecules = 6.25×10^{21} ~~2.84×10^{22}~~ mol

EXAMINER COMMENTARIES
Question 1 – Exemplar 2

(a) and b)(i) correct
(b)(ii) Scores 1 mark for 3 lines in spectrum at the correct *m/z* values. However, abundances are incorrect.
(b)(iii) Scores 1 mark for a transferred error. The response calculates the amount of moles incorrectly and then uses this value appropriately in the second part of the problem.
(c) 3 marks awarded. The student did rearrange the expression and calculate the correct value for n. However they went on to perform an additional unnecessary calculation, confusing 'amount' with 'number'.

Question 1 – Exemplar 3

1 This question is about bromine.

(a) Complete the electronic configuration for a bromine atom, using the s, p, d notation. **(1)**

[Ar] $1s^2 2s^2 2p^6 3s^2 3p^6$

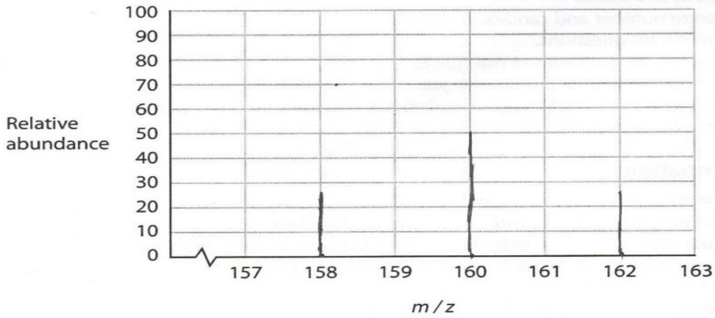
(b) Bromine exists as two isotopes with mass numbers 79 and 81.

(i) Complete the table to show the numbers of subatomic particles in a ^{79}Br atom and a $^{81}Br^-$ ion. **(2)**

Species	Protons	Neutrons	Electrons
^{79}Br	35	44	35
$^{81}Br^-$	35	46	36

(ii) A sample of bromine contained equal amounts of the two isotopes.

Complete the mass spectrum to show the peaks you would expect for Br_2^+ from this sample of bromine gas. **(2)**



(iii) Calculate the number of bromine molecules in 2.00 g of Br_2.

[Avogadro constant = 6.02×10^{23} mol^{-1}] **(2)**

$\frac{2}{159.8}$ = ~~0.01 mol~~ 0.0125 mol

$6.02 \times 10^{23} \times 0.0125$ ~~6.02×10~~ = 7.525×10^{21}

Number of molecules = 7.525×10^{21}

(c) A sample of bromine gas occupied 200 cm^3 at a temperature of 77 °C and a pressure of 1.51×10^5 Pa.

Calculate, using the ideal gas equation, the amount in moles of bromine molecules in this sample.

[$pV = nRT$ $\quad R = 8.31$ J mol^{-1} K^{-1}] **(4)**

~~$1.51 \times 10^5 \times 200 = 8.31 \times 77\, n$~~

~~n = 47197.1~~

200 cm^3 = 0.2 dm^3.

$1.51 \times 10^5 \times 0.2 = 8.31 \times 77\, n$

n = 47.2 mol.

EXAMINER COMMENTARIES
Question 1 – Exemplar 3

(a) and (b) (i) Correct
(b)(ii) 1 mark awarded. This looks like a bar chart and the bars are too wide. The m / z values should be lines at exactly 158, 160 and 162.
(b)(iii) and (c) Correct

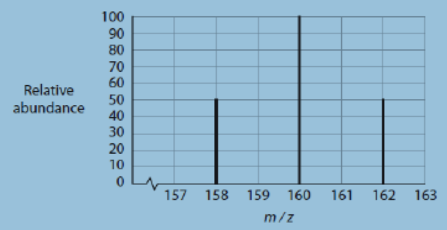
Mark scheme for Question 1

Answer	Additional guidance	Mark
• $[Ar]3d^{10}4s^24p^5$	Allow $4s^23d^{10}4p^5$ Ignore $1s^22s^22p^63s^23p^6$ for (Ar) written out but do not allow incorrect electronic configuration for Ar	1

Answer	Additional guidance	Mark
	1 mark for each row correct	2

Species	Protons	Neutrons	Electrons	
^{79}Br	35	44	35	(1)
$^{81}Br^-$	35	46	36	(1)

Answer	Additional guidance	Mark
		2



Answer		Additional guidance
• lines at 158 and 160 and 162	(1)	
• relative abundances 50:100:50	(1)	Allow relative abundances in any ratio 1:2:1, e.g. 25:50:25

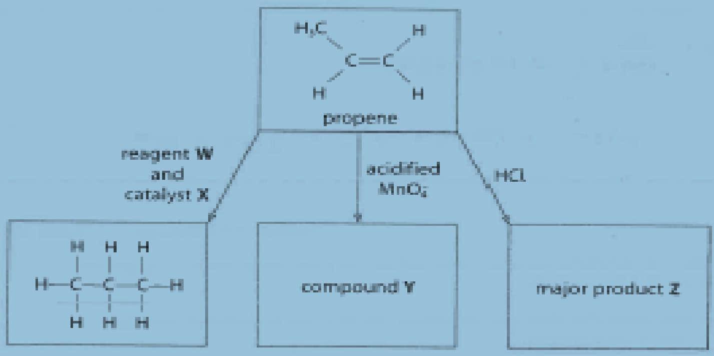
Answer		Additional guidance	Mark
		Example of calculation:	2
• calculation of amount (mol) of Br_2	(1)	Amount of Br_2 = $\frac{2.00}{160}$ = 0.0125 (mol)	
• calculation of molecules of Br_2	(1)	Molecules of Br_2 = 0.0125 × 6.02 × 10^{23} = 7.525 × 10^{21} or Amount of Br_2 = $\frac{2.00}{(2 \times 79.9)}$ = 0.012516 (mol) Molecules of Br_2 = 0.012516 × 6.02 × 10^{23} = 7.5344 × 10^{21} TE on amount Br_2 Correct answer with no working scores both marks Ignore SF except 1 SF	

Answer		Additional guidance	Mark
		Example of calculation:	4
• conversion of volume to m^3	(1)	Volume of bromine = $\frac{200}{1 \times 10^6}$ = 2.00 × 10^{-4} m^3	
• conversion of temperature to K	(1)	77+273 = 350	
• rearrangement of expression	(1)	1.51 × 10^5 × 2.00 × 10^{-4} = n × 8.31 × 350 TE on volume bromine	
• evaluation to give n	(1)	n = $\frac{1.51 \times 10^5 \times 2.00 \times 10^{-4}}{8.31 \times 350}$ n = 1.03834 × 10^{-2} Ignore SF except 1SF Correct answer with no working scores full marks	

Question 2 – Exemplar 1

2 Alkenes contain a double bond between two carbon atoms.

(a) Some reactions of propene are shown.

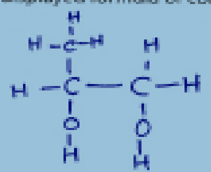


(i) Give the names of reagent W and catalyst X. (2)

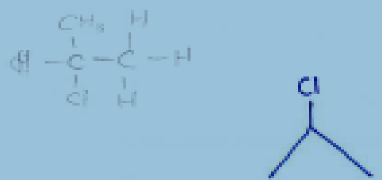
Reagent W .... Hydrogen

Catalyst X .... nickel

(ii) Draw the displayed formula of compound Y. (1)



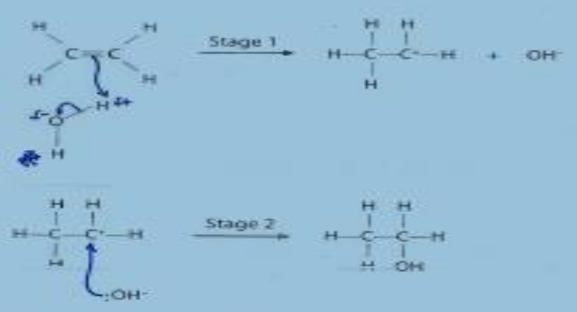
(iii) Draw the skeletal formula of the major product Z. (1)



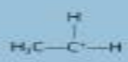
(b) Ethene reacts with steam in the presence of a catalyst to form ethanol.

The mechanism takes place in two stages.

(i) Complete the simplified mechanism for the reaction by adding curly arrows and the relevant dipole.

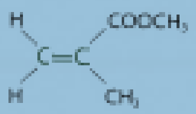


(ii) Predict the shape of the intermediate ion with reference to the positively-charged carbon. Justify your answer.

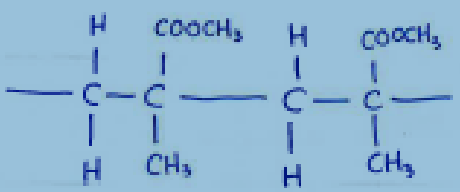


There are 3 bonding electron pairs around the central carbon atom, and there are no lone-pairs of electrons, since there are only 3 electrons around the central carbon atom. In order to minimise repulsion and maximise seperation between the 3 bonding electron pairs, the molecule should have a trigonal planar shape, with 120° angles between the 3 bonds.

(c) Methyl 2-methylpropenoate has the structure:



Draw a section of the polymer formed from methyl 2-methylpropenoate, showing two repeat units.



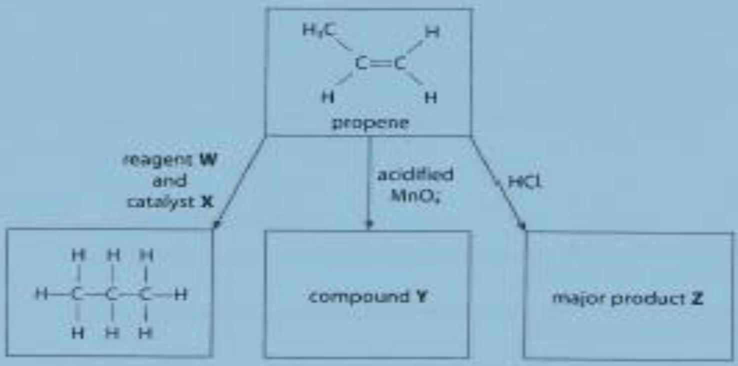
Examiner commentary.
Question 2 – Exemplar 1

All correct and awarded full marks.

Question 2 – Exemplar 2

2 Alkenes contain a double bond between two carbon atoms.

(a) Some reactions of propene are shown.

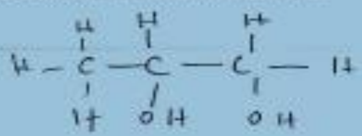


(i) Give the names of reagent **W** and catalyst **X**.

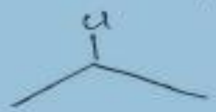
Reagent **W** H2

Catalyst **X** Platinum

(ii) Draw the displayed formula of compound **Y**.



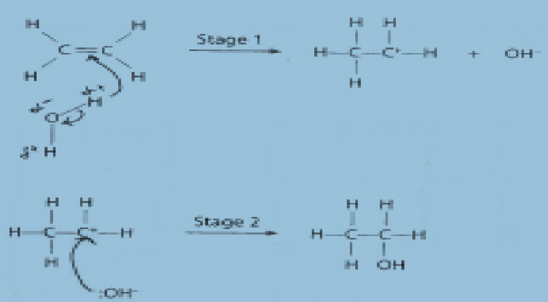
(iii) Draw the skeletal formula of the major product **Z**.



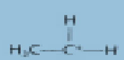
(b) Ethene reacts with steam in the presence of a catalyst to form ethanol.

The mechanism takes place in two stages.

(i) Complete the simplified mechanism for the reaction by adding curly arrows and the relevant dipole.

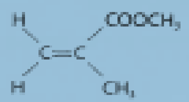


(ii) Predict the shape of the intermediate ion with reference to the positively-charged carbon. Justify your answer.



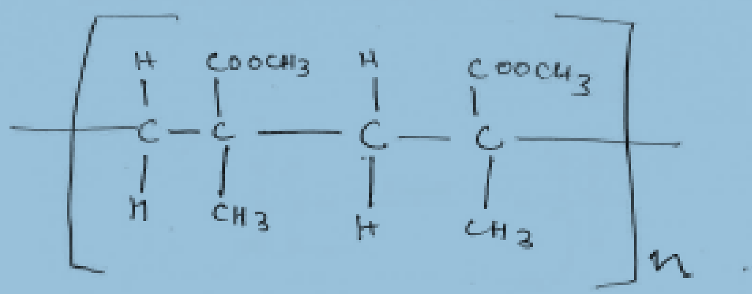
Trigonal planar, C^+ has only 3 bond pairs of electrons surrounding it. The bond pairs separate to points of minimum repulsion.

(c) Methyl 2-methylpropenoate has the structure:



Draw a section of the polymer formed from methyl 2-methylpropenoate, showing two repeat units.

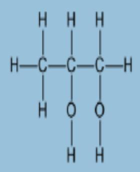
[2]

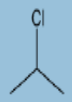


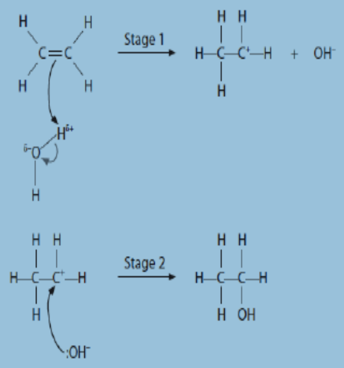
Examiner commentary
Question 2 – Exemplar 2

(a)(i), (ii) and (iii) correct
(b)(i) scores 3 marks – the only error is the direction of the arrow between the C=C and the positive hydrogen
(b)(ii) 3 marks as per the mark scheme
(c) Correct for 2 marks

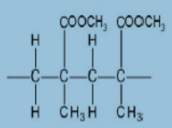
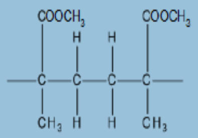
Mark scheme for Question 2

Question number	Answer	Additional guidance	Mark
23(a)(ii)	• 	Allow OH Do not allow C-H-O	1

Question number	Answer	Additional guidance	Mark
23(a)(iii)	• 		1

Question number	Answer	Additional guidance	Mark
23(b)(i)	• correct dipole ($O^{\delta-}$ – $H^{\delta+}$) (1) • curly arrow from C=C to H in H_2O (1) • curly arrow from O-H bond to O (1) • curly arrow from lone pair on O of OH^- to C^+ (1)	Example of mechanism: 	4

Question number	Answer	Additional guidance	Mark
23(b)(ii)	• trigonal planar (1) • 3 bond pairs/electron pairs (around the carbon atom) (1) • bond pairs/electron pairs arranged to minimise repulsion (1)	Allow M1 and M2 shown on a diagram Allow bond pairs/electron pairs as far apart as possible	3

Question number	Answer	Additional guidance	Mark
23(c)	• 4 carbon backbone with continuation bonds (1) • all side chains correct (1)	Example of polymer:  or  Allow CO_2CH_3 in side chains Allow CH_3 and $COOCH_3$ groups above or below the carbon chain Ignore square brackets and n Any structure with C=C scores 0	2

Question 3 – Exemplar 1

3 Ethanedioic acid is a solid diprotic acid. A student used ethanedioic acid in a titration to find the concentration of a potassium hydroxide solution.

The equation for the reaction is:

$$2KOH + (COOH)_2 \rightarrow (COOK)_2 + 2H_2O$$

(a) Calculate the mass of ethanedioic acid that should be used to make $1000\,cm^3$ of a $0.0500\,mol\,dm^{-3}$ solution in water.

Give your answer to an appropriate number of significant figures.

[Molar mass of ethanedioic acid = $90.0\,g\,mol^{-1}$].

1 × 0.05 = 0.5 mol

0.500 × 90.0 = 45g

(b) A student decided to check to see if phenolphthalein was a suitable indicator for this titration. The student measured $400\,cm^3$ of the $0.0500\,mol\,dm^{-3}$ ethanedioic acid into a beaker and added a few drops of phenolphthalein indicator.

Calculate the minimum mass of solid potassium hydroxide that should be added to produce a colour change.

(2)

$400 \times 10^{-3} \times 0.05 = 0.02$ mol

KOH : $(COOH)_2$

2 : 1

x : 0.02

x = 0.02 × 2 = 0.04 mol

0.04 × 56.1 = 2.244 g

*(c) A student used a $0.0500\,mol\,dm^{-3}$ solution of ethanedioic acid to find an accurate concentration of a potassium hydroxide solution which was known to have an approximate concentration of $0.1\,mol\,dm^{-3}$.

Describe a procedure to obtain reliable titration results using standard laboratory equipment.

- Add ethanedioic acid into a burrette so that the menisecus lies on the zero
- ~~to~~ Prepare ~~5~~ 4 ~~con~~ ~~beakers~~ conical flasks each with 5 10 cm^3 of KOH
- Add Pheonpthalene to the KOH
- ~~Have a rough~~
- Have a rough titration. Record the value at which solution goes from pink to colourless
- Add acid upto a point less then rough titre then add ~~dr~~ dropwise
- Close the tap at the exact moment colourchange from pink to ~~co~~ colourless
- Repeat ~~3~~ 3 times
- Take all the concordant values and calculate the average

Question 3 – Exemplar 1

(a) 1 mark awarded as 1 x 0.05 = 0.05 mol, not 0.5

(b) Correct

(c) 3 marks awarded for the ideas of a rough titration, adding the potassium hydroxide dropwise and repeating to obtain concordant results. There is no mention of rinsing the burette and pipette with the solutions they will be measuring, making sure there are no air bubbles in the burette and using a pipette and pipette filler.

Question 3 – Exemplar 2

Marks awarded – Q3a (2) – 1, Q3b (2) -2, Q3C (6) -6

Give your answer to an appropriate number of significant figures.

[Molar mass of ethanedioic acid = 90.0 g mol⁻¹].

[2]

$c = \frac{n}{v}$

$n = cv$

$= 0.05 \times \frac{1}{1000}$

$= 0.05$ mol.

mole ratio

H_2O : $(COOH)_2$

2 : 1

0.05 : n

2n = 0.05

$n = \frac{0.05}{2}$

= 0.025 mol.

mass = n × mr

= 0.025 × 90

= 2.25g //

(b) A student decided to check to see if phenolphthalein was a suitable indicator for this titration. The student measured 400 cm³ of the 0.0500 mol dm⁻³ ethanedioic acid into a beaker and added a few drops of phenolphthalein indicator.

Calculate the minimum mass of solid potassium hydroxide that should be added to produce a colour change.

[2]

$c = \frac{n}{v}$

$n = cv$

$= 0.05 \times \frac{400}{1000}$

= 0.02 mol.

mole ratio

KOH : $(COOH)_2$

2 : 1

n : 0.02

n = 0.02 × 2

= 0.04

mass = n × mr

= 0.04 × (39.1 + 16 + 1)

= 2.244 g //

wash the burette with distilled water and then with a little bit of KOH. Place a funnel on top of the burette and add the KOH. Open the tap and allow some of the KOH to run out. This makes sure that there are no air bubbles in the stem of the burette and ensures that the antijet is filled with the KOH(aq). Wash the beaker with distilled water. Wash the pipette with distilled water and then with little bit of the ethanedioic acid using a pipette filler. Fill the pipette with ethanedioic acid until the lower meniscus is on the mark of the pipette. Hold the conical flask at an angle and allow the $(COOH)_2$ to drain along the wall of the conical flask. Add a few drops of phenolphthalein to the conical flask. Add the solution in the burette to the conical flask until the colour of phenolphthalein changes and note the final volume. This is an approximate titre. Empty the contents of the beaker and wash thoroughly. Repeat the procedure but this time add the KOH(aq) slowly when few cm³ short of the approximate titre. And finally dropwise. Make sure you constantly swirl. Repeat the same procedure until concordant readings are obtained

Mark scheme for Question 3

Answer		Additional guidance	Mark
		Example of calculation:	2
• calculation of number of moles	(1)	$0.0500\ cm^3$ ($\times$ 1000 ÷ 1000) = 0.0500 (mol)	
• evaluation to 2/3 SF	(1)	(0.0500×90.0) = 4.50 (g)	

Answer		Additional guidance	Mark
An answer that make reference to the following points:		Example of calculation:	2
• moles of ethanedioic acid	(1)	Moles acid = $400 \times 0.0500 \div 1000 = 2.00 \times 10^{-2}$	
• moles of potassium hydroxide and mass of potassium hydroxide.	(1)	Moles KOH = $2.00 \times 10^{-2} \times 2 = 4.00 \times 10^{-2}$ mol $4.00 \times 10^{-2} \times 56.1 = 2.24(4)$ g Correct answer with no working scores 2 Ignore SF except 1 SF	

Answer	Additional guidance	Mark
This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content.	Guidance on how the mark scheme should be applied. The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning, scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages). In general, it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning. If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded, do not deduct mark(s). Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning.	6

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5-4	3
3-2	2
1	1
0	0

The following table shows how the marks should be awarded for structure and lines of reasoning.

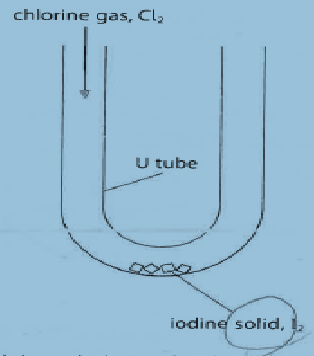
	Number of marks awarded for structure and sustained lines of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.	2
Answer is partially structured with some linkages and lines of reasoning.	1
Answer has no linkages between points and is unstructured.	0

Answer	Additional guidance	Mark
Indicative points: • rinse glassware with appropriate solutions • fill the burette with potassium hydroxide solution, ensuring there are no air bubbles • use a pipette and pipette filler to transfer $25.0\ cm^3$ / $10\ cm^3$ of acid to a conical flask • (add indicator to the acid in the conical flask and) carry out a range finder/rough titration • add potassium hydroxide drop by drop near the end point • repeat titrations until concordant/within ± $0.2\ cm^3$.	Do not award just 'rinse with distilled water'. Alternative IP 2 to 5 if acid (solution) used in burette: • fill the burette with (ethanedioic) acid solution, ensuring there are no air bubbles • use a pipette and pipette filler to transfer $25.0\ cm^3$ of potassium hydroxide solution to a conical flask • (add indicator to the potassium hydroxide in the conical flask and) carry out a range finder/rough titration • add (ethanedioic) acid drop by drop near the end point.	

Question 4 – Exemplar 1

4 Iodine monochloride, ICl, is a covalent compound produced by the reaction of iodine with chlorine. Iodine monochloride is a dark brown liquid at room temperature.

The equipment shown can be used to pass chlorine over solid iodine to produce iodine monochloride.



When excess chlorine is passed through the U tube, the iodine monochloride reacts to produce iodine trichloride in an equilibrium reaction.

(a) Write a chemical equation for the reaction of iodine with chlorine to produce iodine monochloride. Include state symbols.

(2)

$I_{2(s)} + Cl_{2(g)} \longrightarrow 2ICl_{(l)}$

(b) The iodine monochloride molecule has a permanent dipole. Complete the following table using the electronegativity data from your Data Booklet and hence show the dipole on the diagram of the iodine monochloride molecule.

(1)

Element	Electronegativity
Cl	
I	

I—Cl

(c) Iodine monochloride reacts with propene to form two isomeric products. This is an addition reaction that is similar to the reaction of propene with hydrogen halides.

(i) Draw the skeletal formulae of both isomers.

(2)

(ii) Explain which of these isomers is the major product.

(3)

Since the secondary carbocation is more stable, the iodine attaches to the carbon atom the more hydrogens ∴ the major product is 2-chloro-1-iodopropane.

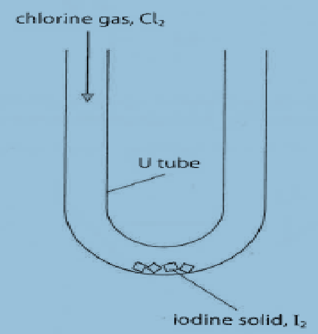
Examiner commentary
Question 4 – Exemplar 1

(a) Correct
(b) Not attempted
(c) (i) Correct
(c) (ii) 2 marks awarded for the major product and the secondary carbocation is more stable (than the primary carbocation). The answer would need to refer to the δ+ on iodine and that it is attacked by the π electrons in propene for the third mark.

Question 4 – Exemplar 2

4 Iodine monochloride, ICl, is a covalent compound produced by the reaction of iodine with chlorine. Iodine monochloride is a dark brown liquid at room temperature.

The equipment shown can be used to pass chlorine over solid iodine to produce iodine monochloride.



When excess chlorine is passed through the U tube, the iodine monochloride reacts to produce iodine trichloride in an equilibrium reaction.

(a) Write a chemical equation for the reaction of iodine with chlorine to produce iodine monochloride. Include state symbols.

(2)

$I_{2(s)} + Cl_{2(g)} \rightarrow 2ICl_{(l)}$

(b) The iodine monochloride molecule has a permanent dipole. Complete the following table using the electronegativity data from your Data Booklet and hence show the dipole on the diagram of the iodine monochloride molecule.

(3)

Element	Electronegativity
Cl	3·0
I	2·5

$\overset{+\delta}{I}$—$\overset{-\delta}{Cl}$

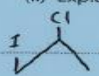
(c) Iodine monochloride reacts with propene to form two isomeric products. This is an addition reaction that is similar to the reaction of propene with hydrogen halides.

(i) Draw the skeletal formulae of both isomers.

(2)

(ii) Explain which of these isomers is the major product.

(3)



, this 1-Iodo-2-Chloropropane is the major product as Iodine which has a +δ charge is added to the carbon which has the most hydrogen atoms already attached to.

Examiner commentary
Question 4 – Exemplar 2

(a) (b) and (c)(i) all correct

(c)(ii) The correct isomer has been identified so 1 mark awarded. The student has realised that iodine has the slight positive charge but has not followed this by stating that it will be attacked by the pi electrons in the C=C bond, so misses out on the second mark.

Mark scheme for Question 4

Question number	Answer	Additional guidance	Mark
23(a)	• balanced equation (1) • all states correct (1)	$I_2(s) + Cl_2(g) \rightarrow 2ICl(l)$ Accept multiples	2

Question number	Answer	Additional guidance	Mark
23(b)	• correct electronegativity values and correct dipole diagram	Cl = 3.0 and I = 2.5 $\delta+$ I—Cl $\delta-$ Do not award full charges	1

Question number	Answer	Additional guidance	Mark
23(c)(i)	• 1 mark each correct formula	 Allow 1 mark for 2 correct non-skeletal formulae	2

Question number	Answer	Additional guidance	Mark
23(c)(ii)	An explantion that makes reference to the following points: • identification of correct isomer (1) • iodine is $\delta+$ and is attacked by the π electrons (1) • more stable secondary carbocation formed. (1)	2-chloro-1-iodopropane	3

Question 5 – Exemplar 1

5 A class of students carried out experiments to determine the value of x in the formula of hydrated sodium carbonate, $Na_2CO_3.xH_2O$.

Hydrated sodium carbonate was heated until no more water of crystallisation remained. Anhydrous sodium carbonate, Na_2CO_3, was formed.

$$Na_2CO_3.xH_2O \rightarrow Na_2CO_3 + xH_2O$$

The students were given the following instructions:

- weigh a sample of the hydrated sodium carbonate in a pre-weighed crucible
- heat the crucible containing the sample to remove the water of crystallisation
- allow the crucible to cool and then reweigh the crucible.

A student's results are shown in Table 3.

(a) Complete Table 3.

(2)

Measurement	Value / g
Mass of crucible empty	19.36
Mass of crucible + hydrated sodium carbonate	26.06
Mass of crucible + anhydrous sodium carbonate	21.98
Mass of hydrated sodium carbonate	6.70
Mass of anhydrous sodium carbonate	2.62
Mass of water removed	4.08

Table 3

(b) (i) Calculate the number of moles of water removed on heating the hydrated sodium carbonate.

(1)

moles = $\frac{4.08}{18}$ = 0.227 mol

(ii) Calculate the number of moles of anhydrous sodium carbonate, Na_2CO_3, formed after heating.

(1)

moles = $\frac{2.62}{106}$ = 0.0247 mol

(iii) Use your answers from (b)(i) and (b)(ii) to calculate the value of x. Give your answer to **three** significant figures.

(2)

H_2O	:	Na_2CO_3
0.227	:	0.0247
9.17	:	1

x = 9.17

(c) **Each** use of the balance to find a mass reading in the table has a maximum uncertainty of ±0.005 g.

Calculate the percentage error in the measurement of the mass of the crucible and hydrated sodium carbonate (26.06 g) before heating.

(1)

0.005 × 2 = $\frac{0.01}{26.06}$ × 100

= 0.0384 %

(d) The Data Book value for x is 10.

One student obtained a value for x of 8.63 and another student obtained a value for x of 10.79.

Explain the practical errors that could have led to each of these values.

[4]

The Value ~~for~~ of 10.79 could have been because some ~~salt~~ of the salt would have ~~been~~ escaped from the crucible during heating. This would have ~~given a~~ led to a lower mass of anhydrous salt being collected at the end of the experiment, which would have led to a value of x that is higher than the actual value since there would have been less moles of Na_2Cl. The value ~~for~~ of 8.63 could have been because ~~the~~ not all of the water escaped from the sodium carbonate. This would have led to an increase in the mass of anhydrous salt, which would have decreased the value of x, since the number of moles of ~~Na~~ anhydrous sodium carbonate would have increased and the number of moles of water would have decreased.

(e) Devise an experiment involving a titration that could be used to determine the value of x in $Na_2CO_3.xH_2O$.

List the essential steps in the practical procedure.

You are not expected to explain how the data is used to calculate **x**.

[5]

~~To determine x~~ Dissolve a fixed mass of hydrated sodium carbonate in fixed volume of water to form an alkaline solution. Slowly Add phenopthalein indicator to the solution. Fill a burette with ~~the~~ hydrochloric acid of a fixed concentration and titrate the sodium carbonate with the hydrochloric acid till the ~~indicator~~ solution turns pale pink. Calculate the ~~volume of the~~ number of moles of HCl required to neutralize the ~~salt~~ Na_2CO_3.

Examiner commentary
Question 5 – Exemplar 1

(a) , (b)(i), (b)(ii), (b)(iii) and (c) Correct
(d) 3 marks awarded. Both marks are awarded for explaining why 10.79 is too high and 1 mark for the ideas that not all of the water has evaporated to explain 8.63. Another mark would be scored for a reason for this, e.g. it wasn't heated for long enough
(e) 3 marks awarded. The only marking point missing is to repeat the titration to obtain concordant titres.

Question 5 – Exemplar 2

5 A class of students carried out experiments to determine the value of **x** in the formula of hydrated sodium carbonate, $Na_2CO_3.xH_2O$.

Hydrated sodium carbonate was heated until no more water of crystallisation remained. Anhydrous sodium carbonate, Na_2CO_3, was formed.

$$Na_2CO_3.xH_2O \rightarrow Na_2CO_3 + xH_2O$$

The students were given the following instructions:

- weigh a sample of the hydrated sodium carbonate in a pre-weighed crucible
- heat the crucible containing the sample to remove the water of crystallisation
- allow the crucible to cool and then reweigh the crucible.

A student's results are shown in Table 3.

(a) Complete Table 3. (2)

Measurement	Value / g
Mass of crucible empty	19.36
Mass of crucible + hydrated sodium carbonate	26.06
Mass of crucible + anhydrous sodium carbonate	21.98
Mass of hydrated sodium carbonate	6.70
Mass of anhydrous sodium carbonate	2.62
Mass of water removed	4.08

Table 3

(b) (i) Calculate the number of moles of water removed on heating the hydrated sodium carbonate. (1)

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

$= 4.08/18 = 0.227$ mol

(ii) Calculate the number of moles of anhydrous sodium carbonate, Na_2CO_3, formed after heating. (1)

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

$= 2.62/106 = 0.0247$ mol

(iii) Use your answers from (b)(i) and (b)(ii) to calculate the value of **x**. Give your answer to **three** significant figures. (2)

~~0.0247 : 0.227~~

$x = 0.227/0.0247$

$x = 9.19$

(c) **Each** use of the balance to find a mass reading in the table has a maximum uncertainty of ±0.005 g.

Calculate the percentage error in the measurement of the mass of the crucible and hydrated sodium carbonate (26.06 g) before heating. (1)

$\%\ error = \frac{total\ uncertainty}{measured\ value} \times 100$

$= \frac{0.005 \times 2}{26.06} \times 100$

$= 0.0384\%$

(d) The Data Book value for **x** is 10.

One student obtained a value for **x** of 8.63 and another student obtained a value for **x** of 10.79.

Explain the practical errors that could have led to each of these values.

(4)

For the student who obtained x = 8.63, the student may not have successfully evaporated all of the water of crystallization. That Therefore the mass measured of anhydrous Na_2CO_3 may have been large therefore giving a smaller value of x than the data booklet.

For the student who obtained x = 10.79, may have lost some of the hydrated Na_2CO_3 due to a transfer loss, therefore the value of mass of anhydrous Na_2CO_3 would decrease therefore giving a value of x larger than the one in the data booklet.

(e) Devise an experiment involving a titration that could be used to determine the value of **x** in $Na_2CO_3.xH_2O$.

List the essential steps in the practical procedure.

You are not expected to explain how the data is used to calculate **x**.

(5)

Examiner commentary
Question 5 – Exemplar 2

(a), (b) and (c) all correct

(d) Line 2 scores a mark for the idea that not enough water has been removed and line 6 scores a mark for the idea that some extra material has been lost. To gain more credit the student would have to discuss a reason for the insufficient water loss and be more precise about where the material was lost from.
(e) Not attempted

Question 5 – Exemplar 3

5 A class of students carried out experiments to determine the value of x in the formula of hydrated sodium carbonate, $Na_2CO_3.xH_2O$.

Hydrated sodium carbonate was heated until no more water of crystallisation remained. Anhydrous sodium carbonate, Na_2CO_3, was formed.

$$Na_2CO_3.xH_2O \rightarrow Na_2CO_3 + xH_2O$$

The students were given the following instructions:

- weigh a sample of the hydrated sodium carbonate in a pre-weighed crucible
- heat the crucible containing the sample to remove the water of crystallisation
- allow the crucible to cool and then reweigh the crucible.

A student's results are shown in Table 3.

(a) Complete Table 3. (2)

Measurement	Value / g
Mass of crucible empty	19.36
Mass of crucible + hydrated sodium carbonate	26.06
Mass of crucible + anhydrous sodium carbonate	21.98
Mass of hydrated sodium carbonate	6.7
Mass of anhydrous sodium carbonate	2.62
Mass of water removed	4.08

Table 3

(b) (i) Calculate the number of moles of water removed on heating the hydrated sodium carbonate. (1)

$n = \frac{M}{Mm} = \frac{4.08}{18} = 0.2266$

$= 0.227$ mol

(ii) Calculate the number of moles of anhydrous sodium carbonate, Na_2CO_3, formed after heating. (2)

$n = \frac{M}{Mm} = \frac{2.62}{106} = 0.0247$ mol

(iii) Use your answers from (b)(i) and (b)(ii) to calculate the value of x. Give your answer to **three** significant figures. (2)

$Na_2CO_3 + xH_2O \rightarrow Na_2CO_3 \cdot xH_2O$

$Na_2CO_3 : H_2O$

~~0.227 : 0.0247~~

~~0.0247~~ ~~0.0247~~

$0.0247 : 0.227$

$1 : 9.19$

$x = 9.19$

(c) Each use of the balance to find a mass reading in the table has a maximum uncertainty of ±0.005 g.

Calculate the percentage error in the measurement of the mass of the crucible and hydrated sodium carbonate (26.06 g) before heating. (1)

% error $= \frac{0.005}{26.06} \times 100$

$=$ ~~0.0384%~~

$= 0.0192\%$

(d) The Data Book value for x is 10.

One student obtained a value for x of 8.63 and another student obtained a value for x of 10.79.

Explain the practical errors that could have led to each of these values.

(4)

Handling losses during transfer could have decreased the value of X to 8.63. There could have also been zero error on the balance which results in a higher value of x. Not all the water would have been evaporated when heated therefore this could have decreased the value of X as the mass of water removed is less so the number of moles reduces.

(e) Devise an experiment involving a titration that could be used to determine the value of x in $Na_2CO_3.xH_2O$.

List the essential steps in the practical procedure.

You are not expected to explain how the data is used to calculate x.

(4)

Fill the burette with H_2SO_4.
Then pipette out 10cm³ of $Na_2CO_3 \cdot XH_2O$ and add it into a conical flask. Add a few drops of phenolphthalein into the solution. Add the acid into the alkaline dropwise and note down the volume required for phenolphthalein to turn from colourless to pink.

Examiner commentary
Question 5 – Exemplar 3

(a)1 mark awarded for 2 correct values. The mass of hydrated sodium carbonate should be 6.70 to match the 2 d.p. for all the other masses in the table.
(b) all correct
(c) No credit given as student has not noticed the balance is used twice to find the mass of carbonate.
(d) The student has linked the lower value of x to insufficient water removal, so scores 1 mark. To gain more credit the student will have to consider why all the water has not been removed, as well as discuss errors linked to the higher value of x
(e) A very brief outline of the process is described but only the choice of an indicator scores a mark. To gain further credit the student needs to think about the quantitative nature of the solutions required and the need for concordant results.

Mark scheme for Question 5

Answer	Additional guidance	Mark
mass of hydrated sodium carbonate: 6.70 mass of anhydrous sodium carbonate: 2.62 mass of water removed / g: 4.08 • all 3 numbers correct (2)	Do not award 6.7 Any 1 or 2 correct (1)	2

Answer	Additional guidance	Mark
• calculation of moles of water	Example of calculation: $\frac{4.08}{18}$ = 0.22666667 (mol) Ignore SF except 1 TE on mass of water in table	1

Answer	Additional guidance	Mark
• calculation of relative formula mass of Na_2CO_3 (1) • calculation of moles of Na_2CO_3 (1)	Example of calculation: 106 = $\frac{2.62}{106}$ = 0.02471698 (mol) Ignore SF except 1 SF TE on mass of Na_2CO_3	2

Answer	Additional guidance	Mark
• calculation of X (1) • answer to 3 SF (1)	Example of calculation: = $\frac{\text{answer to 4(b)(i)}}{\text{answer to 4(b)(ii)}}$ = $\frac{0.22666667}{0.02471698}$ (= 9.17048) 9.17	2

Answer	Additional guidance	Mark
• calculation of percentage uncertainty	Example of calculation: $\frac{2 \times 0.0005}{26.06} \times 100$ = (±)0.0384(%) Ignore SF	1

Answer	Additional guidance	Mark
An explanation that makes reference to: • 8.63 is too low because not enough water has been removed (1) • because it's not been heated long/strongly enough (1) • 10.79 is too high because apparently too much water has been removed/some extra material has been lost (1) • because solid has been lost from the crucible. (1)	Accept hydrated sodium carbonate has lost water in storage Ignore reference to impurities in the sodium carbonate Do not award measurement errors	4

Answer	Additional guidance	Mark
An answer that makes reference to: • dissolve known mass of solid to form a known volume of solution (1) • titrate with hydrochloric acid solution of known concentration (1) • use of methyl orange indicator (and colour change) (1) • repeat to obtain concordant titre values. (1)	Accept prepare a solution of sodium carbonate of known concentration Allow sulfuric/nitric acid Allow use of phenolphthalein Do not award: use of litmus or UI Allow within 0.2 cm^3	4