Examiners' Report
June 2016

IAL Chemistry WCH02 01

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Introduction

The paper seemed to be well received. There was no evidence of candidates having insufficient time to complete the paper. All questions attracted the full range of marks. There were a number of questions on areas of the specification which were less familiar to the candidates. There were also several questions requiring candidates to apply their knowledge to novel situations.

There were several questions on practical areas of this unit. There were many excellent answers from centres where practical work is given the priority needed but there were also candidates who showed little experience of working in laboratories.

There were the usual numbers of questions where candidates failed to read the question asked.

Multiple choice questions 1 – 12

The most accessible questions were:

- **2d** – molecular structure
- **4a –** ketone identification
- **5** – Maxwell-Boltmann curve

The most difficult items were:

- **10b** – uncertainties in titration readings
- **12** – boiling temperature trends for Group 7 hydrides
- **10a** – concentration of a salt formed by neutralization
- **1** – isotopic molecular ion peaks in mass spectroscopy

Question 13 (a)

This question was about the electronic structures and shapes of some fluorides of elements of the first and second short periods of the Periodic Table. Some of these were familiar but some required application of general principles to less familiar molecules.

In part (a), the shape and bond angle for boron trifluoride were well known. A few thought it was a triangular pyramid.

(a) For BCl_3, give the shape of the molecule and give the ClBCl bond angle.

(2)

Shape Trigonal planar

Bond angle 104·5°

ResultsPlus
Examiner Comments

The shape is correct but the bond angle is incorrect.

ResultsPlus
Examiner Tip

Learn the shapes, their names and their bond angles.

Question 13 (b)

The shape needed to be drawn in a recognisable way. It is easiest to represent it as a 'three legged stool' with a 'saw-tooth' convention drawing, with a thickening line showing a bond coming out of the paper and a dotted line for a bond going into the paper.

The bond angle accepted was from 106 – 108°, along with the true value, which turns out to be 102°

Better answers stated that nonbonding pair-bond pair repulsions are greater than bond pair-bond-pair repulsions.

Very good answers also stated that bonding and non-bonding electron pairs arrange themselves to give minimum repulsion at maximum separation.

*(b) For the NCl_3 molecule, draw the shape you would expect, and suggest the ClNCl bond angle. Explain why the molecule has this shape and bond angle.

(4)

Shape

Bond angle 104.5°

Explanation It has ~~to~~ a lone pair and three bond pairs. They get arranged in a way where there is maximum repulsion between each other.

ResultsPlus
Examiner Comments

There are several instructive errors here.

The candidate does not understand the saw-tooth convention, but the shape is clear so this answer was not penalised on this occasion.

The bond angle is incorrect for one non-bonding pair.

The idea of maximum repulsion is entirely incorrect.

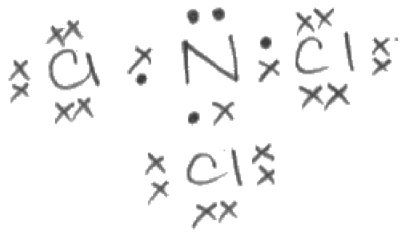
ResultsPlus
Examiner Tip

Learn the 'saw-tooth' convention drawing of bonds, with a thickening line showing a bond coming out of the paper and a dotted line for a bond going into the paper.

Learn the bond angles – 180, 120, 109.5, 107, and 104.5.\

Understand the application of electron pair repulsion.

Shape



Bond angle 107°

Explanation In NCl_3, there are 3 bond pairs of electrons and 1 lone pair of electrons around the central nitrogen atom. ~~lone pairs~~ ~~repel~~ The lone pair repels more than the bond pairs, ~~resulting in minimum~~ resulting in trigonal pyramidal shape where the repulsion is minimum and the separation is maximum

ResultsPlus
Examiner Comments

This is fine apart from the (correct) dot and cross structure.

The question asked for the **shape**.

ResultsPlus
Examiner Tip

The shape of a molecule is a drawing of its three dimensional shape.

Question 13 (c) (i)

It is usual for the sign to precede an oxidation number, so this was penalised. Weaker answers omitted the positive sign.

(c) (i) What is the oxidation number of chlorine in Cl_2O_7?

(1)

-7

$2x + 14 = 0$
$2x = -14$
$x = -7$

ResultsPlus
Examiner Comments

The candidate has muddled the calculation.

According to the rules, as the oxygen is more electronegative, it has charge – 2, so chlorine is +7.

ResultsPlus
Examiner Tip

Learn the rules for determining oxidation number.

(c) (i) What is the oxidation number of chlorine in Cl_2O_7?

(1)

7

$2x + -14 = 0$
$2x = 14$
$\frac{2x}{2} = \frac{14}{2}$
$x = 7$

ResultsPlus
Examiner Comments

Signs must be given with oxidation numbers, and precede them.

ResultsPlus
Examiner Tip

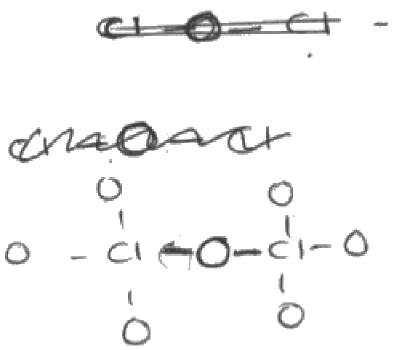
Learn that a sign always precedes an oxidation number, even if it is positive.

Question 13 (c) (ii)

The key to this question was to recognise that all seven outer shell electrons in the chlorine atoms are involved in bonding.

(ii) One oxygen atom bonds to both chlorine atoms in Cl_2O_7. Suggest a displayed formula for Cl_2O_7.

(1)



ResultsPlus
Examiner Comments

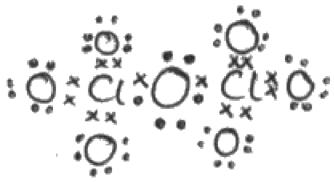
Although the six outer oxygen atoms are bonded with single, rather than double bonds, it was felt this still showed the overall shape of the molecule, and awarded 1 mark.

ResultsPlus
Examiner Tip

In application questions, like this, do what you can to answer them. Do not be put off writing something down, even if you are not sure it is correct.

(ii) One oxygen atom bonds to both chlorine atoms in Cl_2O_7. Suggest a displayed formula for Cl_2O_7.

(1)



ResultsPlus
Examiner Comments

The question asks for a **displayed** formula.

ResultsPlus
Examiner Tip

Read the question carefully – you should underline key words like 'displayed'.

Question 13 (c) (iii)

Though the question had clearly stated that a single product forms, many candidates ignored this, giving two products.

(iii) Water reacts with Cl_2O_7 to form a single product. Suggest the equation for this reaction. State symbols are not required.

(1)

$Cl_2O_7 + H_2O \rightarrow 2HCl + 3\frac{1}{2}O_2$

ResultsPlus
Examiner Comments

This has two errors.

'...form a single product' has been ignored.

The equation does not balance for oxygen.

ResultsPlus
Examiner Tip

Read the question – underline key words.

Check each atom type balances in equations.

(iii) Water reacts with Cl_2O_7 to form a single product. Suggest the equation for this reaction. State symbols are not required.

(1)

$Cl_2O_7 + H_2O \rightarrow Cl_2O_7.H_2O$

ResultsPlus
Examiner Comments

This was quite a common response.

Though the correct number of each atom are present, it is not acceptable.

ResultsPlus
Examiner Tip

'.H_2O' is a way of representing water within a crystal structure.

Question 14 (a) (i)

Much of this question was centred on the reaction of halogenoalkanes with water containing dissolved silver nitrate, 2.10 2diii in the specification. Reactions which the specification explicitly states should be 'carried out', 2.10 2e. Responses seemed to indicate that many candidates were unfamiliar with these experiments, their results and the significance of the results.

In 14 (a) (i), better responses recognised the oxidizing power of concentrated sulfuric acid, but weaker ones just realised that iodine, rather than hydrogen iodide, is formed.

(a) 1-chlorobutane can be made by adding potassium chloride to a mixture of butan-1-ol and concentrated sulfuric acid.

(i) Explain why it is not possible to make 1-iodobutane from butan-1-ol using potassium iodide and concentrated sulfuric acid.

(2)

Concentrated sulfuric acid reduces iodine ions to iodine. So, -iodobutane will not form.

ResultsPlus
Examiner Comments

There are two errors here.

Sulfuric acid does not reduce, it oxidizes.

Sulfuric acid oxidizes iod**ide** ions not iodine ions.

ResultsPlus
Examiner Tip

Be careful to learn the understanding of oxidation and reduction.

Make sure that you know the correct terms for referring to chemical entities.

(a) 1-chlorobutane can be made by adding potassium chloride to a mixture of butan-1-ol and concentrated sulfuric acid.

(i) Explain why it is not possible to make 1-iodobutane from butan-1-ol using potassium iodide and concentrated sulfuric acid.

(2)

because Iodine is a stronger ~~a~~ reducing agent than chloride and hence it reduces ~~the~~ concentrated ~~sulph~~

ResultsPlus
Examiner Comments

The first statement is allowed, though it is better to refer to the powerful oxidizing nature of sulfuric acid.

The candidate has failed to fully answer the question – the idea that iodide forms iodine has been omitted.

ResultsPlus
Examiner Tip

Answer each question as fully as possible.

Question 14 (a) (ii)

This proved a difficult ask.

Weaker responses sometimes gave the correct equation for the formation of phosphorus triiodide but often failed to balance the equation.

Better responses managed most of the correct entities for the second equation, but very few managed the balancing.

(ii) 1-iodobutane is prepared by adding iodine in small portions to a mixture of red phosphorus and butan-1-ol.

When all the iodine has been added, the mixture is refluxed.

In this reaction, iodine reacts with phosphorus to produce phosphorus triiodide, which then reacts with the butan-1-ol to form 1-iodobutane.

Write an equation for each reaction. State symbols are not required.

(2)

$$3I_2 + 2P \rightarrow 2PI_3$$

$$PI_3 + C_4H_9OH \rightarrow C_4H_9I + POH$$

ResultsPlus
Examiner Comments

The first equation is fine.

The second equation does not balance for iodine.

ResultsPlus
Examiner Tip

The clue to remembering this equation is to learn that H_3PO_3 forms.

In this reaction, iodine reacts with phosphorus to produce phosphorus triiodide, which then reacts with the butan-1-ol to form 1-iodobutane.

Write an equation for each reaction. State symbols are not required.

(2)

$$P + I_2 \longrightarrow PI_3$$

$$\cancel{PI_3 + CH_3CH_2CH_2CH_2Br \longrightarrow CH_3CH_2CH_2CH_2I + P}$$

$$\cancel{PI_3 + CH_3CH_2CH_2CH_2OH \longrightarrow CH_3CH_2CH_2CH_2I + HPIO_3}.$$

$$PI_3 + CH_3CH_2CH_2CH_2OH \longrightarrow CH_3CH_2CH_2CH_2I + \cancel{HPIO_3}\ HIPO_3$$

ResultsPlus
Examiner Comments

Neither equation balances for iodine.

ResultsPlus
Examiner Tip

Check equations balance for each atom type.

Question 14 (b) (i)

Fewer than half the responses were successful.

It is important to consider the reasons for each practical procedure.

Good responses recognised that halogenoalkanes are immiscible with water but soluble in ethanol.

(i) Explain why ethanol is added to each test tube.

(1)

to replace the Halide group.

ResultsPlus
Examiner Comments

This was quite a common misunderstanding.

A solvent is usually just a suitable medium to allow the reactants to mix.

ResultsPlus
Examiner Tip

In practical work, always consider the reasons for each step of a procedure.

(i) Explain why ethanol is added to each test tube.

(1)

It acts as a solvent

ResultsPlus
Examiner Comments

This was the common response, which is not incorrect, but insufficient.

ResultsPlus
Examiner Tip

Answer the question as fully as possible; here 'the solvent for both reactants' would have been enough.

Question 14 (b) (ii)

Only weak responses did not give the appropriate alcohol as the organic product, some giving an alkene.

(ii) Give the name of the organic product which forms in all of these reactions.

(1)

~~Butan-1-ol~~ But-1-ene

ResultsPlus
Examiner Comments

This was the common error.

Notice the candidate has correctly stated which butene would form.

However this is only likely at higher temperature and an alcoholic solution of KOH.

ResultsPlus
Examiner Tip

In organic chemistry learn: the names and formulae of reactants and products AND conditions for each reaction.

(ii) Give the name of the organic product which forms in all of these reactions. (1)

~~Silver halide~~ butanol

~~butanol and butan amix~~

ResultsPlus
Examiner Comments

An instructive common error – the name has been correctly identified but there are two possible isomers. The – 1 – is essential.

ResultsPlus
Examiner Tip

Be critical of your answers – have you really 'nailed' it?

Question 14 (b) (iii)

The correct colour was 'yellow'. Notice shades of yellow were not acceptable. This was the easier mark.

The ionic equation was more challenging. Even those getting to something recognisable as an ionic equation made errors like divalent or trivalent silver, or incorrect states for the product or the reactants.

(iii) The halide ion formed in each reaction reacts with the silver nitrate solution to give a precipitate.

Give the colour of the precipitate formed in test tube **C** and give the ionic equation for the formation of this precipitate.
Include state symbols in your equation.

(2)

Colour Yellow

Equation $2I^- + Ag^{2+} \rightarrow AgI_2$

ResultsPlus
Examiner Comments

This is fine apart from divalent silver.

ResultsPlus
Examiner Tip

Remember to learn the charge on each ion as you meet it in the course.

(iii) The halide ion formed in each reaction reacts with the silver nitrate solution to give a precipitate.

Give the colour of the precipitate formed in test tube **C** and give the ionic equation for the formation of this precipitate.
Include state symbols in your equation.

(2)

Colour .... AgI

Equation ~~Ag~~ $\cancel{NO_3 + OH^- \longrightarrow H_2O + NO_2}$

$Ag^+ + I^- \longrightarrow AgI$

ResultsPlus
Examiner Comments

This is quite sad in many ways, for the candidate knows several things correctly.

The question has been misread twice.

The colour of the precipitate was asked for.

Also 'include state symbols'.

ResultsPlus
Examiner Tip

Read the question carefully – underline key words like colour.

Question 14 (b) (iv)

Only about half the candidates knew these effects of dilute and concentrated ammonia solution on silver halide precipitates.

(iv) Dilute and concentrated aqueous ammonia are added to separate samples of the precipitates formed in test tubes **A** and **C**.

Complete the table.

(2)

	Observation with dilute aqueous ammonia	Observation with concentrated aqueous ammonia
Precipitate from Tube **A**	Precipitate ~~dis~~ dissolves	precipitate dissolves
Precipitate from Tube **C**	precipitate doesn't ~~partially~~ dissolves	precipitate partially ~~doesn't~~ dissolves

ResultsPlus
Examiner Comments

The first line is fine.

Silver iodide does not dissolve.

ResultsPlus
Examiner Tip

Remember the silver halides become less soluble as you go from chloride to iodide.

(iv) Dilute and concentrated aqueous ammonia are added to separate samples of the precipitates formed in test tubes **A** and **C**.

Complete the table.

(2)

	Observation with dilute aqueous ammonia	Observation with concentrated aqueous ammonia
Precipitate from Tube **A**	Precipitate does not dissolve	Precipitate dissolves
Precipitate from Tube **C**	Precipitate does not dissolve	Precipitate does not dissolve

ResultsPlus
Examiner Comments

This time the second line is correct, but the first line refers to silver bromide.

ResultsPlus
Examiner Tip

Had the question been read correctly?

Question 14 (b) (v)

About half the candidates remembered this result correctly.

(v) Give the order in which the precipitates form, in the test tubes **A**, **B** and **C**, giving the fastest first.

(1)

A, B, C.

ResultsPlus
Examiner Comments

This was the most common incorrect response, perhaps based on knowledge of only one mechanism for this reaction.

ResultsPlus
Examiner Tip

The key thing here is to remember the determining factors in rates of hydrolysis of halogenoalkanes.

(v) Give the order in which the precipitates form, in the test tubes **A**, **B** and **C**, giving the fastest first.

(1)

A, B, C.

ResultsPlus
Examiner Comments

It is difficult to see where this sequence comes from. It could be a random guess from someone who has never done the experiment.

ResultsPlus
Examiner Tip

Remember to learn the results of experiments.

Question 14 (b) (vi)

After the mistakes in part (v), it was probably inevitable that the same candidates would struggle with the explanation of the results.

Despite being asked about bond polarity, this part of the question was often ignored.

There was much discussion of steric hindrance, which, while true, missed the main point of the question. The key factor is the ease of breaking of the carbon bromine bond.

*(vi) State how the bond polarities of carbon-halogen bonds vary.

Explain why bond polarity does **not** determine the rate of the reaction between halogenoalkanes and water.

(2)

Bond polarity decreases down the group. As halogen ~~atom~~ atoms get bigger, more electrons cause more sheilding effect, electronegativity decreases, Therefore ~~bon~~ carbon-halogen bond polarity decreases. Bond polarity does not determine the rate of the reaction because they are not very attracted to the δ^+ and δ^- ~~ion~~ charge on hydrogen ion and oxygen ion in water molecule. Polarity of bond can not cause enough attraction between solute-solvent particles.

ResultsPlus
Examiner Comments

This answer has a good section answering the bond polarity part of the question.

ResultsPlus
Examiner Tip

Learn that the governing factor determining the rate of these reactions is the strength of the carbon halogen bond.

Question 14 (c) (i)

A large number of responses gave butan-1-ol as the product, which is incorrect.

The carrying out of this reaction is clearly stated in the specification.

(c) When these halogenoalkanes are heated separately with concentrated potassium hydroxide in ethanol, the same gaseous organic product forms.

(i) Give the structural formula for this organic product.

(1)

$H_2C=CH_2$ C_2H_4

ResultsPlus
Examiner Comments

The formation of ethene was common, which would be correct from a halogenoethane.

ResultsPlus
Examiner Tip

It is rare to change the number of carbons in an organic reaction.

(c) When these halogenoalkanes are heated separately with concentrated potassium hydroxide in ethanol, the same gaseous organic product forms.

(i) Give the structural formula for this organic product.

(1)

~~$CH_3CH_3CH_2OH$~~ $CH_3CH_2CH_2=CH_2$

ResultsPlus
Examiner Comments

Notice the five valent carbon in the formula, otherwise this would be fine.

ResultsPlus
Examiner Tip

Always check in formulae that each carbon forms four bonds.

Question 14 (c) (ii)

The majority of better responses correctly classified this as an elimination reaction.

(ii) State the type of reaction which occurs.

(1)

Substitution reaction.

ResultsPlus
Examiner Comments

This may have been a transferred error, but it was so serious it was not credited.

ResultsPlus
Examiner Tip

In multi-part sections always check the first part very carefully.

Question 14 (c) (iii)

Either the test with bromine **water** or with **acidified** potassium manganate(VII) were fine.

Colour changes were often given the wrong way round.

(iii) Give a chemical test for this organic product and state the colour change that occurs.

(2)

Test Add Bromine water to the solution

Colour change from colourless to Brown.

ResultsPlus
Examiner Comments

Notice the reagent is fine but the colour change is the wrong way round.

ResultsPlus
Examiner Tip

Think about the direction of colour changes in tests.

(iii) Give a chemical test for this organic product and state the colour change that occurs.

(2)

Test Phosphorus pentachoride

Colour change orange to green

ResultsPlus
Examiner Comments

This shows how muddled some candidates can get.

The test is the test for an OH group.

The result is for another reaction entirely.

ResultsPlus
Examiner Tip

Learn tests for common functional groups, with the results of the tests.

Question 14 (d) (i)

This equation should form 1-butylamine and ammonium chloride.

On this occasion credit was given if hydrogen iodide was the inorganic product, though this is very unlikely.

(d) All three halogenoalkanes undergo substitution reactions with ammonia. The initial reaction forms butylamine, $CH_3CH_2CH_2CH_2NH_2$.

(i) Write the equation for the initial reaction of 1-iodobutane with ammonia. State symbols are not required.

(1)

$$CH_3CH_2CH_2CH_2I + NH_3 \rightarrow CH_3CH_2CH_2\overset{NH_2}{C}H_2 + \cancel{H}I_2$$

ResultsPlus
Examiner Comments

This equation fails to balance for hydrogen or iodine.

ResultsPlus
Examiner Tip

Check equations balance.

(d) All three halogenoalkanes undergo substitution reactions with ammonia. The initial reaction forms butylamine, $CH_3CH_2CH_2CH_2NH_2$.

(i) Write the equation for the initial reaction of 1-iodobutane with ammonia. State symbols are not required.

(1)

$$CH_3CH_2CH_2CH_3I + NH_3 \rightarrow CH_3CH_2CH_2CH_2NH_2 + NH_4I.$$

ResultsPlus
Examiner Comments

This answer includes two instructive errors.

The formula for 1-iodobutane has an extra hydrogen.

The equation does not balance for ammonia.

ResultsPlus
Examiner Tip

Check formulae for four bonds per carbon.

Check equations balance.

Question 14 (d) (ii)

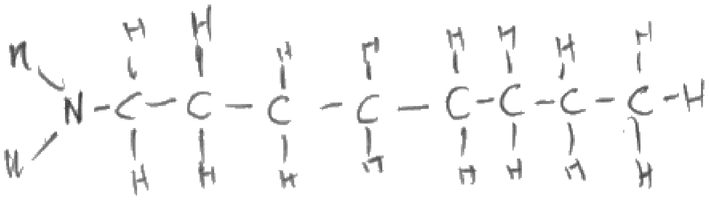
The formation of diamines, triamines and quaternary amines is one of the reasons for the poor yield from this reaction.

The common error in the correct idea was to have too many hydrogens on the nitrogen.

(ii) The butylamine formed also reacts with the 1-iodobutane in a further substitution reaction.

Suggest a structural formula for the product of this reaction.

(1)



ResultsPlus
Examiner Comments

The candidate has the correct idea of combining two organic molecules, but not around the nitrogen.

ResultsPlus
Examiner Tip

The non-bonding electrons on the nitrogen atom, are why this nucleophilic substitution reaction occurs.

(ii) The butylamine formed also reacts with the 1-iodobutane in a further substitution reaction.

Suggest a structural formula for the product of this reaction.

(1)

$(CH_3CH_2CH_2CH_2)_2NH_2$

ResultsPlus
Examiner Comments

The correct answer, apart from an extra hydrogen.

Technically this can form, of course, but it has an extra positive charge.

Question 15 (a) (i)

This was another question based on the candidates' practical experience, results of an experiment and the interpretation of those results.

In part (a) (i), the common incorrect response was BaO.

Some gave an incorrect formula for barium nitrate and a few gave the correct formula for barium nitrite.

Question 15 (a) (ii)

At the high temperature of this decomposition nitrogen dioxide is a red-brown gas.

It is not yellow – a common response.

(ii) What would you see when nitrogen dioxide is given off in Stage 5?

(1)

Pungent smell

ResultsPlus
Examiner Comments

Failure to read the question again – you cannot **see** a smell.

ResultsPlus
Examiner Tip

Observations of all types are important but read the question.

(ii) What would you see when nitrogen dioxide is given off in Stage 5?

(1)

yellow gas

ResultsPlus
Examiner Comments

The common incorrect response.

ResultsPlus
Examiner Tip

At lower temperatures nitrogen dioxide begins to dimerise to produce dinitrogen tetroxide, which is yellow.

Question 15 (a) (iii)

This relatively simple test was known by three quarters of the candidates.

Oxygen does not burn with a squeaky pop, as some thought. They are thinking of hydrogen.

(iii) Describe the test for oxygen and its positive result.

(1)

O_2 formed and bubbles comes out.

ResultsPlus
Examiner Comments

Bubbles do not form in this experiment.

ResultsPlus
Examiner Tip

Carry out experiments, learn the method, the results, and the significance of the results.

(iii) Describe the test for oxygen and its positive result.

(1)

When ~~be~~ a lighted splint is held it relights.

ResultsPlus
Examiner Comments

This was the most common incorrect response.

ResultsPlus
Examiner Tip

A lighted splint might burn more brightly, but this is not the test.

Question 15 (a) (iv)

There was a wide variety of incorrect products in the equation, including hydrogen or nitric oxide, NO.

The water proved too difficult to balance for those who doubled the equation to avoid half a mole of oxygen gas as a product.

(iv) Write the equation for the complete thermal decomposition of hydrated barium nitrate, $Ba(NO_3)_2.4H_2O$.

State symbols are not required.

(2)

$$Ba(NO_3)_2 \cdot 4H_2O \longrightarrow BaO + NO_2 + \frac{3}{2}O_2\ \cancel{O_2/2} + 4H_2O$$

ResultsPlus
Examiner Comments

The entities are correct but the equation does not balance for nitrogen.

ResultsPlus
Examiner Tip

Check that equations balance for each element.

(iv) Write the equation for the complete thermal decomposition of hydrated barium nitrate, $Ba(NO_3)_2.4H_2O$.

State symbols are not required.

(2)

$$Ba(NO_3)_2 \cdot 4H_2O \xrightarrow{heat} Ba(NO_3)_2 + 4H_2O + NO_2 + O_2$$

ResultsPlus
Examiner Comments

This is fully correct apart from balancing for water.

ResultsPlus
Examiner Tip

Remember the number in front in a chemical equation applies to everything in the formula, including water of crystallization.

Question 15 (b)

Various methods were acceptable. Some candidates failed to ensure that either the amounts of the nitrates or the amount of heat was the same.

Ideally the same number of moles should be used and the same Bunsen flame at the same distance from the boiling tube containing the solid.

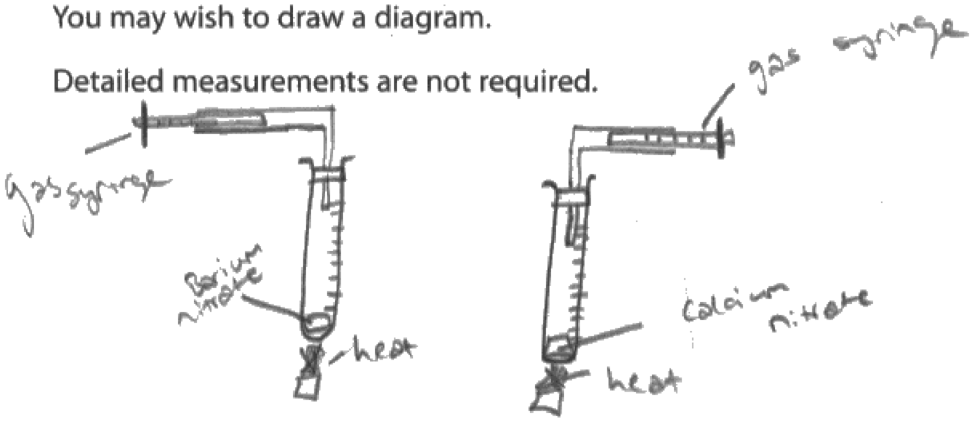
(b) Describe a simple test tube experiment that you can use to compare the thermal stabilities of **anhydrous** barium nitrate and **anhydrous** calcium nitrate.

State **two** essential conditions necessary to ensure a fair test.

You may wish to draw a diagram.

Detailed measurements are not required.

(3)



~~The~~ Two essential conditions necessary to ensure a fair test is the amount of barium nitrate and calcium nitrate should be the same also the amount of heat gives to each.

ResultsPlus
Examiner Comments

This is a very good method.

One improvement could be made to this answer. It should be clarified that the volume of gas in a fixed time should be measured.

Nevertheless, full credit was given for the method, same amounts and same heat.

ResultsPlus
Examiner Tip

Always include all the detail possible.

(b) Describe a simple test tube experiment that you can use to compare the thermal stabilities of **anhydrous** barium nitrate and **anhydrous** calcium nitrate.

State **two** essential conditions necessary to ensure a fair test.

You may wish to draw a diagram.

Detailed measurements are not required.

(3)

Time for limewater to turn milky is measured to compare. for both nitrates, Here, volume of limewater and mass of nitrate with constant flame distance from tube should be maintained for a fair test.

ResultsPlus
Examiner Comments

A common error – to muddle with the formation of carbon dioxide from a carbonate.

Only one mark was lost as the same amount of nitrates and the same heating are clear.

ResultsPlus
Examiner Tip

This is an important experimental set-up to remember.

Question 15 (c)

Care was needed in language in this question.

The relative sizes of the metal **ions** needed to be mentioned.

The greater **polarizing power** of the calcium ion needed to be mentioned.

The calcium ion polarizing/distorting the **negative ion** needed to be mentioned.

*(c) Explain why anhydrous calcium nitrate decomposes more readily than anhydrous barium nitrate.

(3)

$CaCO_3$ decomposes faster as the positive calcium ion is smaller than the positive barium ion, this leads to a smaller ionic radius as compared to the large ionic radius of barium hence resultant increase in ~~~~ polarization of the calcium ion due to higher charge density hence decomposes at a faster rate as compared to $BaNO_3$

ResultsPlus
Examiner Comments

This answer starts well with the smaller calcium ion.

It then states that the calcium ion is more polarized which is wrong.

It is more polarizing of the negative ion.

ResultsPlus
Examiner Tip

Positive ions polarise/are more polarizing.

Negative ions are (more) polarised.

Ca^{2+} has a higher charge and smaller ionic radius. So it has a higher charge density. Hence it ~~pol~~ has a higher ~~polarising~~ polarizing power, ~~so~~ thus ~~distorting the~~ it distorts the electron cloud of the nitrate ion more, ~~decreasing~~ weakening the bonds inside the nitrate ion. Therefore the $Ca(NO_3)_2$ needs less heat to be decomposed.

ResultsPlus
Examiner Comments

This loses the first mark as the calcium ion does not have a higher charge.

Notice this loses the mark for it being smaller.

The rest is fine.

ResultsPlus
Examiner Tip

After answering this type of question where a short paragraph has been written, read through your answer to check it is fully correct.

Question 15 (d)

Flame colours are almost always asked for on this paper and the practical paper. It is worth learning them.

Learn them by colour, and learn the ones which are not some shade of red.

(d) The chlorides of calcium and barium can be distinguished using flame tests.

State what you would see in each test.

(2)

Calcium chloride orange Barium chloride green

ResultsPlus
Examiner Comments

Orange is not a familiar flame colour at this level – brick red is not orange.

ResultsPlus
Examiner Tip

Calcium is one of several ions where its salts colour the flame red (like lithium, strontium and arguably rubidium).

(d) The chlorides of calcium and barium can be distinguished using flame tests.

State what you would see in each test.

(2)

Calcium chloride red Barium chloride pale yellow

ResultsPlus
Examiner Comments

Calcium salts colour the flame red if pure, yellow/red if sodium is present, as it often is.

Barium salts colour the flame pale green, not yellow.

ResultsPlus
Examiner Tip

Ba(g) – Ba is **g**reen

Question 16 (a) (i)

In this question, candidates were not fazed by this unfamiliar titration and calculation.

Some struggled with some of the short answer sections, especially those on practical aspects.

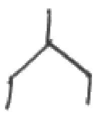
For part (a) (i), all formulae types, displayed, structural, and especially skeletal, for each functional group, should be learned.

(a) Trichloromethane and 1,1,1-trichloroethane are two possible solvents for this reaction.

(i) Give the **skeletal** formulae for trichloromethane and 1,1,1-trichloroethane .

(2)

Trichloromethane



1,1,1-trichloroethane

ResultsPlus
Examiner Comments

The second formula has a glimmer of hope about it: the extra line on the right may be crossed out, but the chlorines have been forgotten.

ResultsPlus
Examiner Tip

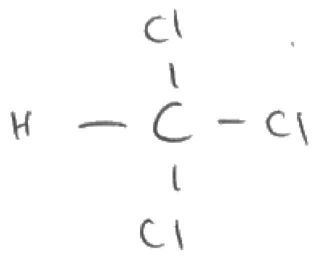
If you make an error in a skeletal formula it is probably better to try again and delete the first attempt.

(a) Trichloromethane and 1,1,1-trichloroethane are two possible solvents for this reaction.

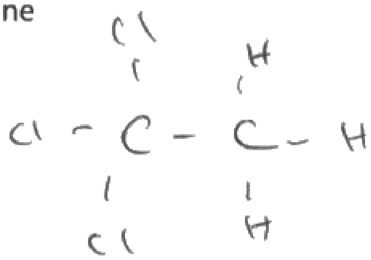
(i) Give the **skeletal** formulae for trichloromethane and 1,1,1-trichloroethane .

(2)

Trichloromethane



1,1,1-trichloroethane



ResultsPlus
Examiner Comments

This was quite a common error – to give displayed formulae.

ResultsPlus
Examiner Tip

Practise writing all formulae types, especially skeletal.

Question 16 (a) (ii)

Weaker responses were that the dipole-dipole forces were greater.

Moderately successful responses realised that London/dispersion forces were greater but attributed this to higher molar mass, or more carbon atoms.

(ii) Explain why 1,1,1-trichloroethane has a higher boiling temperature than trichloromethane.

(2)

1,1,1-trichloroethane has more electrons than trichloromethane. As a result, it has greater unbalanced oscillations, leading to the formation of stronger instantaneous dipoles and induced dipoles. ~~#~~ Therefore, 1,1,1,trichloroethane has greater London forces between its molecules hence a higher boiling temperature

ResultsPlus
Examiner Comments

This is an excellent, well reasoned answer – it does no harm to give correct additional information.

But...

ResultsPlus
Examiner Tip

Only do this if you know you are giving correct additional information.

(ii) Explain why 1,1,1-trichloroethane has a higher boiling temperature than trichloromethane.

(2)

More london forces (stronger) because of extra Carbon higher Mr.

ResultsPlus
Examiner Comments

The stronger intermolecular forces are identified.

Molar mas and number of carbons are not the deepest reasons – the key is the number of electrons.

ResultsPlus
Examiner Tip

Remember that London/dispersion forces depend first on numbers of electrons.

If these are equal, surface area is important.

Question 16 (a) (iii)

The key problem is that they deplete the ozone layer.

Incorrect answers classified it as a CFC or said that chlorine formed.

Of course it was possible to mention the formation of chlorine radicals, provided this was linked to ozone layer depletion.

(iii) Suggest why solvents such as trichloromethane and 1,1,1-trichloroethane are no longer used.

(1)

they are not good solvents

ResultsPlus
Examiner Comments

These are excellent solvents.

ResultsPlus
Examiner Tip

The main reason they are not used is that their vapours are narcotics.

(iii) Suggest why solvents such as trichloromethane and 1,1,1-trichloroethane are no longer used.

(1)

Since they form poisonous ~~chlorone~~ chlorine fumes.

ResultsPlus
Examiner Comments

This was another common incorrect response.

ResultsPlus
Examiner Tip

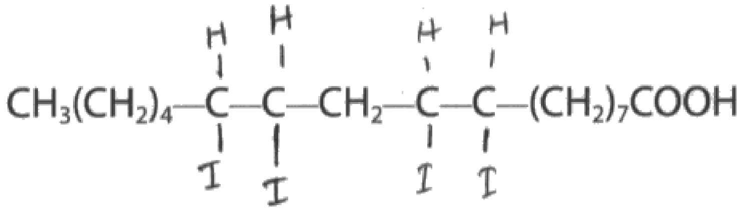
Compounds of chlorine do not usually form chlorine gas/Cl_2.

Question 16 (b) (i)

Less than one quarter of candidates gained the credit here: some only added iodine or chlorine across each double bond rather than both elements; the two hydrogen atoms were also ignored or lost; some only added across one double bond.

(b) (i) Complete the formula of the product when iodine monochloride reacts with linoleic acid, $CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$, the most abundant unsaturated compound in sunflower oil.

(1)



ResultsPlus
Examiner Comments

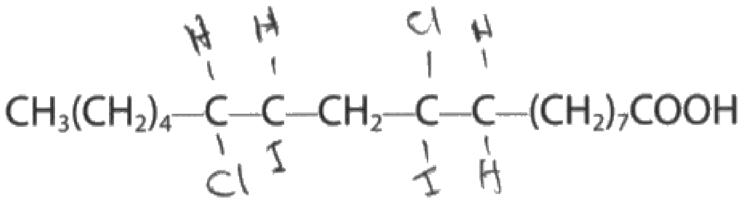
Only iodine has been added rather than ICl.

ResultsPlus
Examiner Tip

Had the question been read correctly?

(b) (i) Complete the formula of the product when iodine monochloride reacts with linoleic acid, $CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$, the most abundant unsaturated compound in sunflower oil.

(1)



ResultsPlus
Examiner Comments

There are two errors here:

- The first iodine has no bond to it.
- More seriously, the iodine and chlorine on the left are added to the same carbon atom.

ResultsPlus
Examiner Tip

The key to understanding addition reactions is the positive part goes to one end and the negative part to the other.

Question 16 (b) (ii)

Incorrect answers often discussed negative chloride ions attacking the double bond.

Some discussed the polarity of the C-Cl bond!

(ii) Iodine monochloride solution is preferred to iodine solution for this reaction because it is more reactive.

Explain why this is so.

(1)

The I-Cl is easily broken due to difference in electronegativity.

ResultsPlus
Examiner Comments

This answer goes part of the way but misses the key consequence that the bond is polar.

ResultsPlus
Examiner Tip

At this level it is important to develop each point as much as possible.

(ii) Iodine monochloride solution is preferred to iodine solution for this reaction because it is more reactive.

Explain why this is so.

(1)

Iodine mono chloride has a longer bond length and lower bond strength than ~~than~~ Iodine solution, so it is more reactive

ResultsPlus
Examiner Comments

This was a good idea, but it is not true. The bond is shorter and stronger.

ResultsPlus
Examiner Tip

Here the key to reactivity is the polarity of the I-Cl bond.

Question 16 (b) (iii)

Many answers based on just 'light', rather than sunlight or UV were deemed insufficient.

(iii) Suggest why Wijs solution is stored in a brown bottle.

(1)

Since the solution of Wijs is supposed to stand in the dark. Hence no light penetrates the bottle.

ResultsPlus
Examiner Comments

No mention of UV or sunlight.

ResultsPlus
Examiner Tip

High energy light is sunlight which contains UV.

(iii) Suggest why Wijs solution is stored in a brown bottle.

(1)

Because iodine monochloride is a brown solution. To indicate there ~~are~~ is iodine in the bottle

ResultsPlus
Examiner Comments

This was a remarkably common response.

ResultsPlus
Examiner Tip

Brown bottles are preferred so that UV or sunlight cannot decompose the contents.

Question 16 (b) (iv)

The oxidation number of iodine (+1) in the first formula was sufficient, with the other entities' oxidation numbers correct for the first mark.

As it was an unfamiliar compound, ICl as the oxidant was sufficient for the second mark, though strictly it is the iodine in the ICl.

(iv) The equation for the reaction between iodide ions and iodine monochloride is given below.

Show that this is a redox reaction by giving all the oxidation numbers and identifying the oxidizing agent.

(2)

	ICl	+	I^-	$\rightarrow$	I_2	+	Cl^-
Oxidation numbers	0		-1		0		-1

Oxidizing agent ICl

ResultsPlus
Examiner Comments

This is another common wrong answer for the oxidation numbers, with a zero beneath the ICl.

ResultsPlus
Examiner Tip

Oxidation numbers apply to elements with compounds and not compounds themselves.

(iv) The equation for the reaction between iodide ions and iodine monochloride is given below.

Show that this is a redox reaction by giving all the oxidation numbers and identifying the oxidizing agent.

(2)

	ICl	+	I^-	$\rightarrow$	I_2	+	Cl^-
Oxidation numbers	+1 -1 0		-1		0		-1

Oxidizing agent Iodine

ResultsPlus
Examiner Comments

This gained credit as both oxidation numbers were given for the elements in ICl.

The zero underneath it was ignored.

The problem with the oxidant is there are two iodines on the RHS of the equation.

ResultsPlus
Examiner Tip

Always be as specific as possible.

Question 16 (c) (i)

It seems reasonable that those who have done iodine titrations should know that the colour changes from red-brown to pale yellow, before the starch is added.

Fewer than one in five candidates knew this.

(c) (i) Starch solution is usually added as an indicator towards the end of the titration.

Describe how the colour of the mixture would change during the titration, **before** starch is added.

(1)

Yellow/brown to Colourless.

ResultsPlus
Examiner Comments

This was the most common incorrect answer.

ResultsPlus
Examiner Tip

Only very dilute solutions of iodine are pale yellow.

(c) (i) Starch solution is usually added as an indicator towards the end of the titration.

Describe how the colour of the mixture would change during the titration, **before** starch is added.

(1)

colour changes to yellow

ResultsPlus
Examiner Comments

The final colour of yellow was acceptable provided it was from brown/red/brown.

ResultsPlus
Examiner Tip

A colour change is always from.... to....

Question 16 (c) (ii)

This question has been asked before, yet less than a quarter of candidates knew the correct answer.

(ii) Explain why starch solution is not added at the start of the titration.

(1)

~~It~~ This would make starch react irreversibly with I_2.

ResultsPlus
Examiner Comments

This answer sets off correctly but is insufficient.

ResultsPlus
Examiner Tip

The reason for adding the starch later is because, if it is added too early, an insoluble starch-iodine complex forms.

Question 16 (d)

In spite of this being an unfamiliar titration, this calculation was well done, with the numerical parts usually correct.

Some halved or doubled their answer to (ii) to get their answer (iii).

Some realised a negative answer could not be possible in (iv) and reversed the subtraction.

Some failed to remember iodine is I_2 in part (vi).

(d) In the blank titration, 40.0 cm^3 of 0.100 mol dm^{-3} sodium thiosulfate solution reacted with 10.0 cm^3 of Wijs solution.

(i) Calculate the number of moles of 0.100 mol dm^{-3} sodium thiosulfate that reacted in the **blank** titre.

(1)

$n = C \times V$

$= 0 \cdot 100 \times \frac{40 \cdot 0}{1000} = 4 \times 10^{-3}$ mols.

(ii) Calculate the number of moles of iodine, I_2, which reacted with the thiosulfate solution in the blank titration.

$S_2O_3^{2-} : I_2$ $\quad \overset{4\times10^{-3}}{2S_2O_3^{2-}}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$

(1)

$2 : 1$

$4\times10^{-3} : x$

$x = \frac{4\times10^{-3}}{2} = 2\times10^{-3}$ mols.

(iii) Using your answer to (d)(ii), and the equation in (b)(iv), deduce the corresponding number of moles of iodine monochloride solution in 10.0 cm^3 of Wijs solution.

(1)

$\frac{2\times10^{-3} \text{ mols}}{2} = 1\times10^{-3}$ mols

~~no. of moles of iodine below = no. of moles of iodine above.~~

(iv) The number of moles of iodine monochloride left after reacting the Wijs solution with the sample of the sunflower oil, calculated from the titre, is 1.10×10^{-3} mol.

Use this, and your answer to (d)(iii), to calculate the number of moles of iodine monochloride that reacted with the sample.

(1)

$\cancel{2\times10^{-3} - 1.10\times10^{-3} = 9\times10^{-4}}$ ~~mols.~~

$1 \cdot 10\times10^{-3} - 1 \cdot 0\times10^{-3} = 1\times10^{-4}$ mols.

(v) Your answer to (d)(iv) is equal to the number of moles of iodine that would have reacted with 0.2 g of sunflower oil.

Calculate the number of moles of iodine that would have reacted with 100 g of sunflower oil.

(1)

~~n =~~ ~~n = 100~~

$0.2g \rightarrow \cancel{9\times10^{-4}}\ 1\times10^{-4}$ mols

$100g \rightarrow x$

$x = \frac{100 \times 1\times10^{-4}}{0.2} = 0.05$ mols.

(vi) Calculate the mass of iodine, I_2, which would have reacted with 100 g of sunflower oil, which is the iodine value for the sunflower oil.

(1)

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

$Mr = 2 \times 126.9 = 253.8$ of I_2

$0.05 = \frac{m}{253.8}$

$m = 12.7g$.

ResultsPlus

Examiner Comments

This is fine until the error in (iii).

There is no transferred error mark in (iv), because the subtraction is done incorrectly. If done correctly it would give a negative answer, which should have encouraged the candidate to go back and check previous steps.

However (v) and (vi) were both given transferred error credit.

ResultsPlus

Examiner Tip

If you get a negative amount of moles in a calculation, go back and check to find your error.

(d) In the blank titration, 40.0 cm³ of 0.100 mol dm⁻³ sodium thiosulfate solution reacted with 10.0 cm³ of Wijs solution.

(i) Calculate the number of moles of 0.100 mol dm⁻³ sodium thiosulfate that reacted in the **blank** titre.

n = number of moles

(1)

$C = \frac{n}{V}$ n = 0.004 moles

$0.1 = \frac{n}{0.04}$

(ii) Calculate the number of moles of iodine, I_2, which reacted with the thiosulfate solution in the blank titration.

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

(1)

S_2O_3 : I_2
2 : 1
0.004 : x

$x = \frac{0.004}{2}$
= 0.002 moles

(iii) Using your answer to (d)(ii), and the equation in (b)(iv), deduce the corresponding number of moles of iodine monochloride solution in 10.0 cm³ of Wijs solution.

(1)

0.002 moles//

(iv) The number of moles of iodine monochloride left after reacting the Wijs solution with the sample of the sunflower oil, calculated from the titre, is 1.10 × 10⁻³ mol.

Use this, and your answer to (d)(iii), to calculate the number of moles of iodine monochloride that reacted with the sample.

(1)

$1.10 \times 10^{-3} = 0.0011$

no of moles = 0.002 + 0.0011
= 3.1×10^{-3} moles.

(v) Your answer to (d)(iv) is equal to the number of moles of iodine that would have reacted with 0.2 g of sunflower oil.

Calculate the number of moles of iodine that would have reacted with 100 g of sunflower oil.

(1)

~~m~~ n : m

3.1×10^{-3} : 0.2

n : 100

$n = 3.1\times10^{-3} \times \frac{100}{0.2}$

$= 1.55$ moles

(vi) Calculate the mass of iodine, I_2, which would have reacted with 100 g of sunflower oil, which is the iodine value for the sunflower oil.

(1)

n : m

0.002 : 0.2

n : 100

$n = 0.002 \times \frac{100}{0.2}$

$= 1$ mol

ResultsPlus

Examiner Comments

This is another example of why it is correct to continue, after making an error.

Everything is fine until step (iv) when the candidates adds rather than subtracts 1.1×10^{-3}.

Notice they get a transferred error mark in part (v).

They fail to multiply their answer to (v) by 253.8 in (vi).

ResultsPlus

Examiner Tip

It is worth persevering even after mistakes.

Question 16 (e)

This was one of the most difficult parts of the paper.

Candidates struggled to understand that less double bonds would lead to a higher sample titre and hence a lower iodine value.

(e) Butter contains a smaller percentage of unsaturated molecules than sunflower oil.

Would the titre value and iodine value for butter be higher, lower or about the same as the values for sunflower oil?

(1)

Titre value About the same

Iodine value lower

ResultsPlus
Examiner Comments

The first statement is incorrect, the second correct.

ResultsPlus
Examiner Tip

If less double bonds are present the first titration must be higher as less ICl will have reacted.

(e) Butter contains a smaller percentage of unsaturated molecules than sunflower oil.

Would the titre value and iodine value for butter be higher, lower or about the same as the values for sunflower oil?

(1)

Titre value Higher

Iodine value Higher

ResultsPlus
Examiner Comments

The first statement is correct.

The second is incorrect.

ResultsPlus
Examiner Tip

Always consider the effects of changes in concentrations for titrations.

Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- Carry out the experiments, considering why procedures are being used and how they work.
- Learn results of experiments.
- Learn the significance of experimental results.
- Practise calculations to find volumes, concentrations, and masses of reactants and products for familiar and unfamiliar reactions.

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