Examiners' Report
January 2013

GCE Chemistry 6CH02 01

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January 2013

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Introduction

This paper tested a wide range of Unit 2 material and provided good opportunities for candidates to show their knowledge and understanding of the chemistry covered by the Specification.

The quality of written communication was very variable, and in some cases, responses were unable to be rewarded as the meaning was unclear. In the calculations on this paper, the routine calculations for the iodine/thiosulfate titrations were well done. One calculation tested understanding of the procedure by asking why a certain amount of potassium iodide was suitable; this was often not attempted, and when a calculation was done it was often not relevant to the question. The calculation of percentage difference in titration readings produced a lot of rounding errors. One question asked for an experimental method to compare the thermal stability of two carbonates. Some answers were excellent but many of the procedures proposed would be impossible to carry out in practice, or would not give the data necessary for the comparison. The answers suggested that many candidates have little experience of doing experiments, or attempting to solve practical problems.

Question 21 (a) (i)

This question was well answered. Most candidates were able to identify the three oxidation numbers of chlorine, but some did not specify the substance in which they were found. Other candidates gave charges instead of oxidation numbers, saying that Cl^- and Cl^+ formed. This was not given credit. Only a very small minority thought that the oxidation numbers of hydrogen and oxygen were changing in the reaction.

Careful use of language was needed to gain the third mark. The definition of disproportionation was generally well known, but some answers just said that oxidation and reduction were occurring. It was necessary to say that the same species, or element, was both oxidized and reduced.

Answers saying that that "disproportionation has occurred because chlorine has gone from 0 to +1 and -1", were not allowed as this statement is just repeating the values of the oxidation numbers.

21 Chlorine is used to prevent the growth of bacteria in swimming pool water. It reacts as shown below.

$$\underset{0}{Cl_2(aq)} + \underset{+2\ -2}{H_2O(l)} \rightleftharpoons \underset{+1\ -1}{HCl(aq)} + \underset{+1+1-2}{HClO(aq)}$$

(a) (i) By giving appropriate oxidation numbers, explain why this is a disproportionation reaction.

(3)

Dis~~pa~~proportionation reaction occurs when an ~~ele~~ atom of an element is oxidized ~~a~~ and reduced in the same reaction. In this case chlorine is oxidized from 0 to +1 and is also reduced from 0 to -1. Therefore, since chlorine has been oxidized and ~~g~~ reduced, it is a disproportion reaction ~~as~~ since it has both accepted and lost electrons.

ResultsPlus
Examiner Comments

This candidate has given the three oxidation numbers correctly but not identified the compounds in which the oxidation number is -1 and +1.

ResultsPlus
Examiner Tip

In disproportionation the same type of atom is both oxidized and reduced, but remember that a single atom cannot be oxidized and reduced simultaneously. This answer was allowed but it would have been better to make it clear that the changes are not happening to the same atom.

21 Chlorine is used to prevent the growth of bacteria in swimming pool water. It reacts as shown below.

$$Cl_2(aq) + H_2O(l) \rightleftharpoons HCl(aq) + HClO(aq)$$

(a) (i) By giving appropriate oxidation numbers, explain why this is a disproportionation reaction.

(3)

Chlorine's oxidation number to start with is 0 because the molecule is diatomic. It is then split and oxidised to −1 in HCl and reduced to +1 in HClO. This reaction is a disproportionation reaction because the chlorine is both oxidised and reduced.

ResultsPlus
Examiner Comments

This candidate has confused the oxidation number changes associated with oxidation and reduction, by saying that production of HCl is oxidation. However the oxidation numbers are correct.

ResultsPlus
Examiner Tip

During reduction the oxidation number is reduced i.e. gets less.

Question 21 (a) (ii)

Many candidates correctly stated that the equilibrium would move to the left, and then said this meant that more reactants would form. This simply rephrases the first statement, and was not allowed as an explanation. A comment about using up some of the added hydrochloric acid or restoring equilibrium was needed. Le Chatelier's principle was sometimes quoted, but to gain credit, it had to be applied to this equilibrium, and just saying that the equilibrium moves to counteract the change in the system did not do this.

(ii) State and explain the effect on the position of equilibrium if concentrated hydrochloric acid is added to a sample of chlorinated swimming pool water.

(2)

The equilibrium would shift to the left as system opposes change, so an increase in HCl would mean the ~~sys~~ equilibrium shifts to the left due to an increase in pressure/ concentration of HCl.

ResultsPlus
Examiner Comments

This answer gives the correct effect on the position of equilibrium. However, more is required in the explanation than saying that when HCl is added, the equilibrium moves to the left because the HCl concentration has increased.

ResultsPlus
Examiner Tip

The reverse reaction will occur when the HCl concentration is increased. This restores equilibrium by using up some of the added HCl and converting it to chlorine and water. All the added HCl will not be used up - if it was, the concentration of the substances on the left of the equation would be higher than they were in the original equilibrium state.

(ii) State and explain the effect on the position of equilibrium if concentrated hydrochloric acid is added to a sample of chlorinated swimming pool water.

(2)

The position would not change because an increase in moles would increase the concentration equally - the number of moles on each side are equal.

ResultsPlus

Examiner Comments

When equilibrium is reached again after concentrated hydrochloric acid is added, both reactants and products will be more concentrated but it is incorrect to say that the equilibrium position would not change.

The number of moles on each side of the equation is important in equilibrium reactions involving gases, as a change in pressure will cause a change in equilibrium position. However, in this reaction the species are all in solution.

ResultsPlus

Examiner Tip

You need to consider the number of moles on each side of the equation in equilibrium reactions involving gases, as a change in pressure will cause a change in equilibrium position. However, in this reaction the species are all in solution so you just have to think about the effect of a change in concentration of one of them.

Question 21 (b) (i)-(vi)

There were many incorrect half-equations given in (i), some with incorrect numbers of electrons and others showing no electrons at all. Candidates are more likely to balance the charges correctly if the charge on the electrons is shown. However it appeared as if some candidates did not know that half-equations included electrons.

The equations given in (ii) were more often correct, and were marked independently of the half-equations in (i). Overall equations should not show electrons. The common error was in the number of hydrogen ions, and if candidates had checked the total charge on each side of the equation they might have realised their mistake.

The calculation of the number of moles of iodine in (iii) was usually well done, though a few candidates stopped at the stage of calculating moles of thiosulfate ions. These candidates rarely said what their numbers referred to, making it difficult for them to gain marks as transferred errors. Very few errors in significant figures or rounding of values were seen here. If an equation was given in (ii), the calculation of the number of moles of ClO^- should have been based on this and the number of moles of iodine calculated in (iii).

Calculation of the concentration in (iv) sometimes caused difficulty; a few were out by a factor of ten and volumes of bleach other than 25 cm^3 were used. The number of moles was sometimes multiplied by the volume instead of being divided by it. Candidates are advised to give numbers in standard form, otherwise zeros were often lost going from one part of a question to another.

In (vi), many candidates simply confirmed that 1.5 g of potassium iodide contained 9.04×10^{-3} moles, as stated in the question. They needed to show that this amount of potassium iodide was an excess, either by calculating the number of moles of iodide ions which reacted with the ClO^-, or comparing the number of moles of ClO^- which could react with 9.04×10^{-3} moles of iodide with the number present in the bleach.

(b) In a similar reaction, chlorine reacts with sodium hydroxide to make household bleach.

$$Cl_2(aq) + 2NaOH(aq) \rightarrow NaCl(aq) + NaClO(aq) + H_2O(l)$$

The concentration of NaClO in diluted bleach was measured by titration. A 25.0 cm^3 sample of bleach was pipetted into a conical flask. Approximately 1.5 g of solid potassium iodide and 10 cm^3 of hydrochloric acid with concentration 2.00 mol dm^{-3} were added. Each mole of ClO^-, from the NaClO in the solution of bleach, produced one mole of iodine, I_2, which was titrated with sodium thiosulfate solution.

(i) Complete the ionic half-equations below for the reaction of ClO^- with acidified potassium iodide by balancing them and **adding electrons** where required.

(2)

$$ClO^- + \ldots 2 \ldots H^+ + 2e^- \rightarrow Cl^- + H_2O$$

$$\ldots 2 \ldots I^- \rightarrow I_2 + 2e^-$$

(ii) Use your answer to (a)(i) to write the overall ionic equation for the reaction between ClO^- and I^- ions in acidic conditions.

(1)

$$ClO^- + 2H^+ + 2I^- \rightarrow I_2 + Cl^- + H_2O$$

(iii) The iodine in the sample required a mean (average) titre of 24.20 cm^3 of 0.0500 mol dm^{-3} sodium thiosulfate solution. Thiosulfate ions react with iodine as shown below.

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

Calculate the number of moles of iodine in the solution.

(2)

$n(S_2O_3^{2-}) = 0.05 \times 0.02420$
$= 1.21 \times 10^{-3}$

$n(I_2) = (1.21 \times 10^{-3}) \div 2$
$= 6.05 \times 10^{-4}$

(iv) What is the number of moles of ClO^- ions in the sample of diluted bleach?

(1)

$n(ClO^-) = 6.05 \times 10^{-4}$

(v) Hence calculate the concentration, in mol dm^{-3}, of ClO^- in the diluted bleach.

(1)

$C = \dfrac{6.05 \times 10^{-4}}{0.025} = 0.0242$ moldm^{-3}

(vi) 1.5 g of potassium iodide, KI, contains 9.04×10^{-3} mol of I^-. Use your answers to (b)(ii) and (b)(iv) to show by calculation why this amount was suitable.

(2)

mole ratio 1 : 2

$(6.05 \times 10^{-4} \times 2) = 1.21 \times 10^{-3}$
$= 0.00121$ moles (I^- required)

$9.04 \times 10^{-3} = 0.00904$ (added)

0.00904 moles added of I^- which is more than required.

ResultsPlus
Examiner Comments

This is an example of an excellent answer. The equations are clearly set out; in the calculations it is clear what each number refers to.

(b) In a similar reaction, chlorine reacts with sodium hydroxide to make household bleach.

25

$$Cl_2(aq) + 2NaOH(aq) \rightarrow NaCl(aq) + NaClO(aq) + H_2O(l)$$

The concentration of NaClO in diluted bleach was measured by titration. A 25.0 cm^3 sample of bleach was pipetted into a conical flask. Approximately 1.5 g of solid potassium iodide and 10 cm^3 of hydrochloric acid with concentration 2.00 mol dm^{-3} were added. Each mole of ClO^-, from the NaClO in the solution of bleach, produced one mole of iodine, I_2, which was titrated with sodium thiosulfate solution.

(i) Complete the ionic half-equations below for the reaction of ClO^- with acidified potassium iodide by balancing them and **adding electrons** where required.

(2)

$ClO^- +$ ....2.... $H^+ \rightarrow Cl^- + H_2O$

....2.... $I^- \rightarrow I_2$

(ii) Use your answer to (a)(i) to write the overall ionic equation for the reaction between ClO^- and I^- ions in acidic conditions.

(1)

$ClO^- + 2H^+ + 2I^- \rightarrow Cl^- + H_2O + I_2$.

(iii) The iodine in the sample required a mean (average) titre of 24.20 cm^3 of 0.0500 mol dm^{-3} sodium thiosulfate solution. Thiosulfate ions react with iodine as shown below.

2 : 1/2

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

Calculate the number of moles of iodine in the solution.

(2)

$V = 24.2\ cm^3$

$c = 0.05$

$n = \frac{V \times C}{1000}$

$= 1.21 \times 10^{-3}$

~~In~~

$n \text{ in } I_2 = \frac{1.21 \times 10^{-3}}{2}$

$= 6.05 \times 10^{-4}$.

(iv) What is the number of moles of ClO^- ions in the sample of diluted bleach?

(1)

$= 6.05 \times 10^{-4}$.

(v) Hence calculate the concentration, in mol dm^{-3}, of ClO^- in the diluted bleach.

(1)

$n = V \times c$

$$c = \frac{n}{V} = \cancel{\frac{6.05 \times 10^{-4}}{24.2}} \qquad \frac{6.05 \times 10^{-4}}{35 \div 1000} = 0.0173 \text{ mol dm}^{-3}$$

~~$c = 2.5 \times 10^{-5}$ moldm^{-3}~~

(vi) 1.5 g of potassium iodide, KI, contains 9.04×10^{-3} mol of I^-. Use your answers to (b)(ii) and (b)(iv) to show by calculation why this amount was suitable.

(2)

1.5g kI = 9.04×10^{-3}

$$n = \frac{m}{mr} = \frac{1.5}{166} = 9.04 \times 10^{-3}$$

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Examiner Comments

In this answer no electrons are shown in the half-equations in (i).

In (iii) the number of moles of iodine is labelled as such, and ideally the number of moles of thiosulfate ions would be labelled too. The volume used to calculate the concentration in (v) is incorrect, and the calculation in (vi) is not based on the reacting ratios of iodide and ClO^- ions.

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Examiner Tip

The charge on each side of an equation should be balanced. The first equation here has a total of one positive charge on the left and one negative charge on the right. When writing half-equations, balance the numbers of atom of each element first, then balance the charge by adding electrons to the side where they are needed.

Question 21 (b) (vii)

This was a simple calculation, but errors occurred when candidates rounded the answer wrongly. The correct value was sometimes rounded to 1%, which was not allowed. Some candidates used very complicated methods for the calculation. This increased their chances of making an error.

(vii) A student carrying out this titration measured the mean (average) titre as 24.50 cm^3.

What is the percentage difference in this student's titre, compared with the accurate value of 24.20 cm^3?

(1)

$\cancel{\frac{24.80}{24.20} \times 100}$

$\frac{0.3}{24.20} \times 100$

1.23

ResultsPlus
Examiner Comments

The value of 1.239 has been rounded incorrectly.

(vii) A student carrying out this titration measured the mean (average) titre as 24.50 cm^3.

What is the percentage difference in this student's titre, compared with the accurate value of 24.20 cm^3?

(1)

$\% \text{ difference} = \frac{(24.50 - 24.20)}{24.20} \times 100\%$

$= \frac{0.3}{24.20} \times 100\%$

$= 1.24\%$ //

$= \pm 0.62\%$ //

ResultsPlus
Examiner Comments

This candidate wrongly thought that an error of 1.24% meant it could be either higher or lower by 0.62%.

ResultsPlus
Examiner Tip

The question gives a titration value which is 0.30 cm^3 above the accurate one. This is not an error which could either be above or below the correct value.

Question 21 (b) (viii)

The question was about a titration value which was higher than the accurate one, so reasons for the difference had to be consistent with a higher titre. Suggestions such as impurities in the solution would affect both a student and a more accurate worker, so these were not allowed. Simply saying that the student had overshot the end-point was rephrasing the fact that the titre was too high, and a reason why this might have happened was required. Many answers referred to human error, but something more specific was required.

(viii) The difference between the student's mean titre and the accurate value was **not** due to the limitations in the accuracy of the measuring instruments.

Suggest one possible reason for this difference.

(1)

Due to the subjective nature of when the titration has gone to completion ie when the indicator has truly changed colour is difficult to ascertain.

ResultsPlus
Examiner Comments

The judgement of when the colour changes is subjective, and was one of the allowed answers.

(viii) The difference between the student's mean titre and the accurate value was **not** due to the limitations in the accuracy of the measuring instruments.

Suggest one possible reason for this difference.

(1)

Some amount reacted with the ~~a~~ air so it got lost.

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Examiner Comments

If the chlorine in the bleach had evaporated the titre would have been lower. Reaction with the air would not occur.

ResultsPlus
Examiner Tip

In a question like this you have to think why the titration reading might be too high, but factors which affect an accurate worker as well as a student could not cause the difference.

Question 21 (c)

This was answered correctly by most candidates, though a few just said that the ozone layer would be affected, rather than making clear that it would be depleted. Many added comments saying that chlorine radicals were involved, or stated the consequences of the thinning of the ozone layer.

A minority of answers said, incorrectly, that the damaging effect was global warming or acid rain.

(c) Suggest **one** damaging effect to the upper atmosphere which could be caused by the presence of chlorine compounds.

(1)

Chlorine free radicals develop which deplete the ozone layer which means more UV, so more skin cancer

ResultsPlus
Examiner Comments

This was a typical correct answer.

(c) Suggest **one** damaging effect to the upper atmosphere which could be caused by the presence of chlorine compounds.

(1)

Chlorine free radicals develop which deplete the ozone layer which means more UV, so more skin cancer

ResultsPlus
Examiner Comments

This answer is typical of candidates who are not clear about the different environmental problems caused by chemicals in the atmosphere.

ResultsPlus
Examiner Tip

Make sure you know about the causes of acid rain, global warming and ozone depletion. Each of these problems has a different cause.

Question 22 (a) (iii)

The reaction of ammonia with a halogenoalkane was not well known. Even when the products were correct many unbalanced equations were given. If the equation showed formation of the amine plus ammonium bromide, rather than just hydrogen bromide, then two moles of ammonia were needed. The product was often thought to be an amide or a nitrile, and when candidates attempted an IUPAC name for an amine they often omitted the number showing the position of the amine group. Other incorrect suggestions such as butamine appeared regularly.

(iii) Write an equation for the reaction of **X** with an alcoholic solution of ammonia, and name the organic product.

(2)

$$CH_3CH_2CH_2CH_2Br_{(aq)} + NH_{3(aq)} \rightarrow CH_3CH_2CH_2CH_2NH_{2(aq)} + HBr_{(aq)}$$

Name of product ~~Butyl amine~~ Butylamine

ResultsPlus
Examiner Comments
This answer was given both marks.

(iii) Write an equation for the reaction of **X** with an alcoholic solution of ammonia, and name the organic product.

(2)

$$CH_3CH_2CH_2CH_2Br + NH_3 \rightarrow CH_3CH_2CH_2CH_2NH_2 + NH_4Br.$$

Name of product ~~butanamine~~ ~~Butan-1-amine~~ butan-1-amine

ResultsPlus
Examiner Comments
This equation is not balanced. Two moles of ammonia are needed.

A mark was given for this version of the name as the number was included.

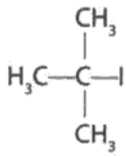
Question 22 (a) (i)-(ii)

The skeletal formula for bromobutane, X, should have shown a zigzag line representing the four carbon atoms, followed by another bond to the bromine atom. Bonds were often drawn of different lengths; this was not penalised. Some very short bonds to Br were shown, but were given the mark as long as they were present. Bonds were often shown at unusual angles, and again this was accepted. A few candidates misread the question, and gave a displayed formula, and displayed or skeletal formulae for Y were sometimes given instead of the name.

22 This question is about two halogenoalkanes, **X** and **Y**, which have the structures shown below.

$CH_3CH_2CH_2CH_2Br$

X



Y

(a) (i) Draw the skeletal formula of **X**.

(1)

(ii) Name **Y**.

(1)

2-methyl-2-iodo propane

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Examiner Comments

This shows a common mistake in the skeletal formula, as it represents a molecule with only three carbon atoms.

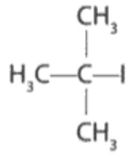
ResultsPlus
Examiner Tip

After drawing the lines representing the carbon skeleton, you need to add another bond going to the other atom or atoms attached to the carbon.

22 This question is about two halogenoalkanes, **X** and **Y**, which have the structures shown below.

$CH_3CH_2CH_2CH_2Br$

X



Y

(a) (i) Draw the skeletal formula of **X**.

(1)

(ii) Name **Y**.

(1)

1, Ido. 111, Trimethyl methane

ResultsPlus
Examiner Comments

This candidate has given two answers and the right hand one is incorrect, as it contains five carbon atoms. The name of Y is also incorrect.

ResultsPlus
Examiner Tip

If you do not want an answer to be marked you must strike it out clearly.

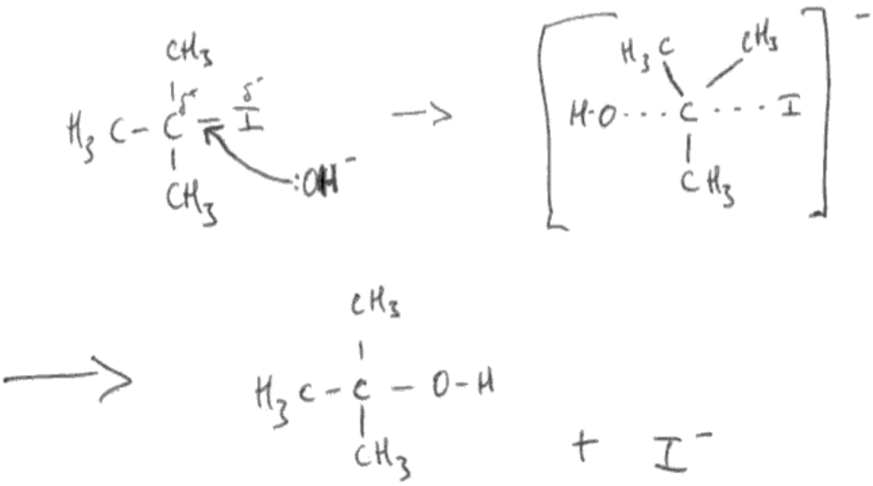
Question 22 (a) (iv)

Most candidates had the correct ideas for this mechanism, though some interpreted a two-step mechanism as being the SN2 mechanism. In this case the transition state was not allowed in place of the carbocation intermediate, but two marks could be gained for showing two correct curly arrows. Some candidates were careless in the positioning of curly arrows, such as the first one coming from the C atom and not the C-I bond. This arrow was often shown going past the I atom into space. A significant minority showed the hydroxide ion attacking the central carbon concurrently with the loss of the iodide ion, but then formed the carbocation intermediate. The intermediate carbocation was often shown with a δ+, rather than a full charge, and the charge on the hydroxide ion was often missing.

There was clearly a lack of understanding that the mechanism represented a sequence of events. Many candidates were confused about the role of potassium, and showed KOH as a covalent molecule, with a curly arrow causing formation of the hydroxide ion.

(iv) When **Y** is heated with an **aqueous** solution of potassium hydroxide, an alcohol is formed in a two-step reaction. Write the mechanism for this reaction using 'curly arrows' where appropriate and clearly showing the structure of the intermediate.

(3)

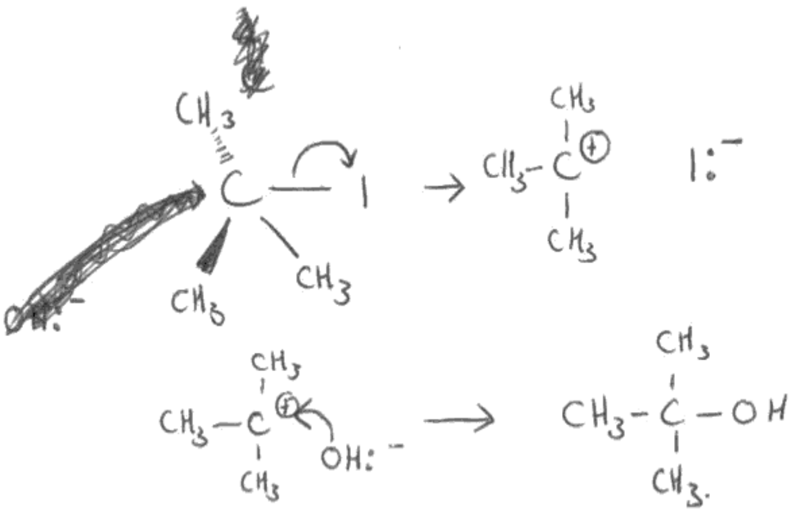


ResultsPlus
Examiner Comments

The mark was allowed for the curly arrow from the hydroxide ion going to the central carbon atom, though its placing could have been better. The transition state was not allowed in place of the intermediate carbocation, and no curly arrow was shown to indicate how the iodide ion was lost, so it scored one mark.

(iv) When **Y** is heated with an **aqueous** solution of potassium hydroxide, an alcohol is formed in a two-step reaction. Write the mechanism for this reaction using 'curly arrows' where appropriate and clearly showing the structure of the intermediate.

(3)



![ResultsPlus]

Examiner Comments

This is an example of an answer which scored all three marks. It was not essential to show the reactant in three dimensions.

Question 22 (a) (v)

The reaction was an elimination, but many candidates expanded on this incorrectly, for example saying that it was elimination/oxidation or electrophilic elimination.

(v) When **Y** is heated with an **alcoholic** solution of potassium hydroxide, the alkene C_4H_8 is formed. What type of reaction occurs to produce the alkene?

(1)

elimination (dehydration)

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Examiner Comments

Water is not lost in this reaction

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Examiner Tip

The reaction is an elimination, but the molecule which is lost is not water. If you are asked for a type of reaction just give one answer.

(v) When **Y** is heated with an **alcoholic** solution of potassium hydroxide, the alkene C_4H_8 is formed. What type of reaction occurs to produce the alkene?

(1)

Dehydrogenation/Elimination

ResultsPlus

Examiner Comments

Hydrogen iodide is eliminated in this reaction, not hydrogen, so this was not allowed.

Question 22 (b)

The silver bromide formed with X would be seen as a cream, off-white or pale yellow precipitate. The description "white" was not allowed. The silver iodide formed with Y would be seen as a yellow precipitate. For full marks it had to be stated that a precipitate formed; the colours alone were not enough for both marks. Some candidates suggested several observations, such as a cream precipitate and evolution of brown fumes or fizzing. This made the overall observation incorrect and was not allowed.

(b) Separate ethanolic solutions of **X** and **Y** were warmed with water containing dissolved silver nitrate. Describe what would be seen in each case, ignoring any differences in the rates of reaction.

(2)

Observation with **X**

~~silver bromide~~ silver bromide ($AgBr$)

Observation with **Y**

(AgI)

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Examiner Comments

The answers given are not observations and did not score.

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Examiner Tip

If you are asked what you would see in a reaction you should give observations, and not just identify the product.

(b) Separate ethanolic solutions of **X** and **Y** were warmed with water containing dissolved silver nitrate. Describe what would be seen in each case, ignoring any differences in the rates of reaction.

(2)

Observation with **X**

Pale - yellow solution

Observation with **Y**

~~white~~ yellow cloudy solution

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Examiner Comments

One mark was allowed here for two correct colours, as there was a contrast between pale yellow and yellow.

ResultsPlus
Examiner Tip

When you describe the product of a reaction, give its colour and its physical state e.g. green gas or, as in this question, yellow precipitate.

Question 22 (c)

The majority of answers stated that the C-Br bond was stronger than the C-I bond, but understanding of the reason for the difference was very limited. As the bromine atom is smaller, the nuclei of the two elements in the bond are closer, but candidates who referred to the ionic radius of bromine did not get the mark. Other candidates thought that intermolecular forces were involved and said that, because the iodine atom had more electrons, its London forces would be greater. Some candidates thought the explanation was the reactivity of bromine compared to iodine. Many candidates answered in terms of the greater electronegativity of bromine causing a greater dipole and increasing the strength of the bond, and this was allowed.

(c) The rates of hydrolysis of primary halogenoalkanes are affected by the strength of the bond between the carbon and the halogen atom.

Is the C—Br bond weaker or stronger than the C—I bond? Explain why the bond strength differs.

(2)

Iodide has a larger ionic radius than bromide. This means the attraction between the ~~outer~~ electrons in the covalent bond and the positively charged nucleus is weaker (also due to more shielding). This means C– Br is stronger.

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Examiner Comments

This candidate refers to the ionic radius of bromine, and then makes a statement which describes why iodine is less electronegative than bromine. Neither comment explains the strength of the bond with carbon.

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Examiner Tip

Short bonds are stronger than long bonds because when the nuclei of one atom are close to the electrons of the other atom they have a stronger attraction.

(c) The rates of hydrolysis of primary halogenoalkanes are affected by the strength of the bond between the carbon and the halogen atom.

Is the C—Br bond weaker or stronger than the C—I bond? Explain why the bond strength differs.

(2)

C - ~~Br~~ I bond stronger, less repulsion of nucleus as electrons sheild repelling and have a stronger attraction to the other elements nucleus.

ResultsPlus

Examiner Comments

This candidate was wrong in choosing C-I as the stronger bond. There is confusion about what two things are attracted in a bond. The nuclei are not attracted, but are held together by their attraction for the shared electrons.

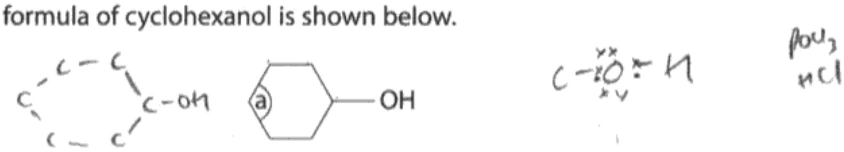
Question 23 (a) (i)-(ii)

The first part of the question asked for a bond angle in cyclohexanol and stated that it differed from the angle in the two dimensional diagram. Many candidates did not realise that the carbon atom involved is bonded to two hydrogen atoms not shown in the skeletal formula, and the most common answer was 120 degrees, though angles from 60 to 200 degrees were seen. As it forms four bonds, the angle would be the normal tetrahedral angle as in methane.

In the second part most candidates realised that the bond angle would change as non-bonding electrons were present on oxygen, but some thought there would only be one lone pair, and answers saying that the bond contained two lone pairs, without specifying that they were on the oxygen did not get the mark. A significant number found difficulty in expressing their answer coherently, and just mentioning maximum separation or minimum repulsion did not get a mark unless it was in a suitable context. In some cases candidates wrote about lone pairs pushing bonding pairs together despite giving an angle in (ii) which was bigger than the angle in (i).

Some candidates did not read the question carefully enough and tried to explain why the bond angle in (i) was 109.5 in terms of bond pairs & lone pairs.

23 The skeletal formula of cyclohexanol is shown below.



(a) (i) The actual bond angles differ from the angles in the two dimensional diagram shown.

What is the angle of the C—C—C bond labelled **a**?

(1)

Angle 120°

*(ii) What is the angle of the C—O—H bond? Justify your answer, explaining why the size of the angle is different from the angle in (i).

(3)

Angle 180°

Explanation ~~O~~ Oxygen has 2 lone pairs, non-bonding pairs of electrons. These repel eachothe to a point of maximum seperation. non-bonding pairs repel more ~~more~~ than bonding pairs.

ResultsPlus
Examiner Comments

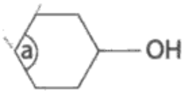
This candidate has drawn the carbon skeleton of cyclohexane, but chosen an incorrect bond angle in (i) as the hydrogen atoms have been forgotten.

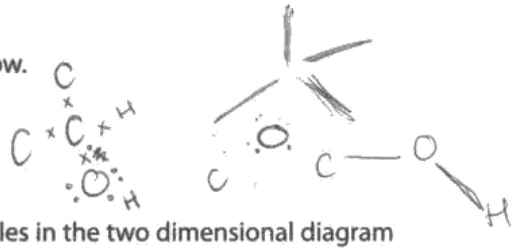
In the second part the bonding electrons have been forgotten, and though the non-bonding electrons are said to repel each other to maximum separation, the bond angle chosen is greater than in (i). The answer got one mark for stating that the oxygen atom had two lone pairs.

ResultsPlus
Examiner Tip

When you have to predict bond angles in skeletal formulae, remember there are hydrogen atoms which are not shown.

23 The skeletal formula of cyclohexanol is shown below.





(a) (i) The actual bond angles differ from the angles in the two dimensional diagram shown.

What is the angle of the C—C—C bond labelled **a**?

(1)

Angle 60°

*(ii) What is the angle of the C—O—H bond? Justify your answer, explaining why the size of the angle is different from the angle in (i).

(3)

Angle ~~60°~~ 104.5°

Explanation ~~Concentrating only on the carbon atom which is bonded~~

The oxygen atom created 2 bonds and has 2 lone pairs. If we treat the lone pairs as bonds then the angle would be 109.5°. There is slightly more repulsion from the two lone pairs so 2.5° is taken off for each. Therefore the angle is 104.5°.

ResultsPlus

Examiner Comments

This candidate has also selected an incorrect bond angle in (i). In (ii) the lone pairs are said to cause more repulsion, presumably meaning more than between bonding pairs, even though the angle suggested is bigger than in (ii) and the third mark was not given here.

Question 23 (b) (i)

There were many very full answers, and only a few identified the products without describing what would be seen. Candidates are likely to have seen this reaction with ethanol and are not expected to know how it might differ with cyclohexanol, so they should have concentrated on changes due to the chemical reaction such as bubbles and a white solid forming along with the disappearance of the sodium. Comments about sodium sinking or floating or going on fire were ignored. Temperature change was not allowed as it is not something which is seen.

(b) (i) Suggest what you would expect to **see** when cyclohexanol reacts with sodium.

(2)

The Na displaces the H & bubbles of hydrogen gas.

and a sodium salt/ precipitate form (white)

ResultsPlus

Examiner Comments

This answer gained both marks for the bubbles and the white precipitate. It was not necessary to identify the chemical products.

Saying that the sodium became coated with a white solid would have been allowed.

(b) (i) Suggest what you would expect to **see** when cyclohexanol reacts with sodium.

(2)

You would see fizzing as the sodium dissolved

and began to react with the cyclohexanol.

ResultsPlus

Examiner Comments

This also was given both marks for the fizzing and dissolving of sodium.

Candidates who said that the cyclohexanol dissolved were not given the mark.

ResultsPlus

Examiner Tip

Remember that fizzing is another word for effervescence, so "fizzing and effervescence" would count as one observation.

Question 23 (b) (ii)

Candidates who used the skeletal formula for cyclohexanol were more likely to get this correct than those who tried to write a molecular formula. Some candidates gave the formula for phenol, C_6H_5OH, rather than $C_6H_{11}OH$. A formula written as $CH_2CH_2CH_2CH_2CH_2CHOH$ was not accepted unless a bond was shown from the first to the sixth carbon. A fully displayed formula was accepted, but would have taken the candidates more time to write than the skeletal formula!

Most candidates got the mark in this question for hydrogen chloride formation, but there were many errors with $POCl_3$ being written as PCl_3, or occasionally $PClO_3$.

(ii) Phosphorus(V) chloride (phosphorus pentachloride) is used to test for the presence of an —OH group. Write the equation for the reaction of cyclohexanol with phosphorus(V) chloride.

(2)

$C_6H_{12}O_{(l)} + PCl_{5(s)} \rightarrow C_6H_{11}Cl_{(aq)} + HCl_{(g)} + POCl_{3(aq)}$

ResultsPlus
Examiner Comments

The correct molecular formula for cyclohexanol was acceptable here as the organic product was correct, and this answer scored both marks.

ResultsPlus
Examiner Tip

It is usually better to give structural formulae rather than molecular formulae in organic reactions because it is easier to see the reaction of the functional group.

(ii) Phosphorus(V) chloride (phosphorus pentachloride) is used to test for the presence of an —OH group. Write the equation for the reaction of cyclohexanol with phosphorus(V) chloride.

(2)

$CH_3CH_2CH_2CH_2CH_2CH_2OH + PCl_5 \rightarrow CH_3CH_2CH_2CH_2CH_2Cl + HCl + POCl_3$

ResultsPlus
Examiner Comments

The formula given is for hexan-1-ol, not cyclohexanol, so though the idea of substitution of Cl for OH is correct it only gets the mark for hydrogen chloride formation.

ResultsPlus
Examiner Tip

The skeletal formula for cyclohexanol was given in the question, and would have been easier to use here.

Question 23 (b) (iii)

Many candidates suggested testing hydrogen chloride with litmus, but this just detects an acidic gas and was not allowed here. When the question asks for a chemical test the answer expected is one where the candidate could write an equation, if asked.

Many answers said that the hydrogen chloride would appear as steamy fumes, which is correct but not a chemical test. Some candidates suggested bubbling the gas into ammonia, rather than allowing it to mix with fumes from ammonia, in which case the dense white smoke would not be seen. Bubbling the gas into silver nitrate solution and seeing a white precipitate was allowed. However if this was in conjunction with the gas bleaching litmus paper it was not.

(iii) Give the chemical test you could use to identify the gas produced, and the observation you would make.

(1)

Moist blue litmus paper would turn red then bleach to identify HCl.

Dense white steamy fumes of HCl would be produced

ResultsPlus

Examiner Comments

The bleaching here would indicate chlorine, and there is no reference to the dense white steamy fumes being formed in a reaction with ammonia.

ResultsPlus

Examiner Tip

If you are asked to give a chemical test, try to think of something more specific than using an indicator.

(iii) Give the chemical test you could use to identify the gas produced, and the observation you would make.

(1)

React with Ammonia, dense white fumes.

ResultsPlus

Examiner Comments

This is an example of one way to score the mark.

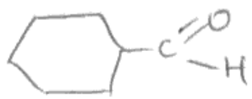
Question 23 (b) (iv)

Cyclohexanol is a secondary alcohol, so would form a ketone on oxidation. Many answers showed formation of a carboxylic acid, with either an extra $-CO_2H$ attached to the ring, or a 5-bonded carbon on the ring connected to an oxygen and an -OH group. Another common error was to break the ring and put a C=O bond either at the end or in the middle of the chain.

(iv) Cyclohexanol reacts with hot acidified potassium dichromate(VI) solution.

Give the skeletal formula of the organic product of this reaction. (1)

aldehyde



ResultsPlus
Examiner Comments

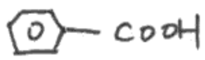
It was common to see an extra carbon atom appearing.

ResultsPlus
Examiner Tip

Cyclohexanol is a secondary alcohol with a ring of six carbon atoms. Reaction with acidified potassium dichromate(VI) solution can't increase the number of carbon atoms!

(iv) Cyclohexanol reacts with hot acidified potassium dichromate(VI) solution.

Give the skeletal formula of the organic product of this reaction. (1)



ResultsPlus
Examiner Comments

The cyclohexanol has gained both an extra carbon atom and a benzene ring in this product.

ResultsPlus
Examiner Tip

Be careful not to mix up the saturated ring in cyclohexanol with a benzene ring.

Question 23 (b) (v)

The colour change of orange to green in this redox reaction was well known.

(v) What colour change would you observe as this reaction takes place?

(1)

From Yellow Orange to Green.

ResultsPlus
Examiner Comments

As potassium chromate(VI) is yellow, the initial colour of yellow-orange was not allowed here.

(v) What colour change would you observe as this reaction takes place?

(1)

From green to orange.

ResultsPlus
Examiner Comments

The colour change must be given the right way round to score the mark.

Question 23 (c)

The question asked for the molecular formula of a fragment of mass 82, so the answer $C_6H_{10}^{(+)}$ should have been deduced from the formula and structure of cyclohexanol. Structural formulae were not accepted, and other formulae with mass 82 such as C_5H_6O were not allowed as they would be unlikely to form from cyclohexanol. If the charge was missing it was not penalised.

(c) The mass spectrum of cyclohexanol has a prominent peak at mass / charge ratio 82.
Suggest the molecular formula of the fragment which causes this peak.

(1)

$CH_2CH_2CH_2CH_2CH_2C$ or C_6H_{10}.

(Total for Question 23 = 12 marks)

TOTAL FOR SECTION B = 41 MARKS

C_6H_{10}.

C_5H

$H_{1/12} = 11 | 12$

$C_5 = 60$

$C_6 = 72$.

$O = 16$.

$CH_2\ CH_2\ CH_2.\ CH_2\ CH_2\ CH_2$.

14 28 42 56 68

ResultsPlus
Examiner Comments

The question asked for a molecular formula, and the answer does not say which of the two versions is the molecular one.

ResultsPlus
Examiner Tip

Make sure you know the difference between a molecular and a structural formula, as a question may ask for a specific type of formula.

(c) The mass spectrum of cyclohexanol has a prominent peak at mass / charge ratio 82. $CH_3CH_2CH_2OH$

Suggest the molecular formula of the fragment which causes this peak. CH_3CH_2OH

(1)

$[C_6H_{13}]^+$ $[C_6H_{10}]^+$

(Total for Question 23 = 12 marks)

TOTAL FOR SECTION B = 41 MARKS

$C_nH_{2n+1}OH$

$48 + 9 + 1 + 16$

$60 + 12 + 16$
$= 88$

$4(12) = 48$
17

C_4H_9

65

OH.

$CH_3CH_2CH_2CH_2CH_2OH$

ResultsPlus
Examiner Comments

When two different answers are given the mark cannot be awarded, even if one is correct.

Question 24 (a)

The link between polar bonds and absorption of infrared radiation due to changes in bond polarity was not well known, though many candidates managed to get one of the two marks.

Many candidates said that carbon dioxide is a polar molecule which is incorrect. It contains polar bonds, which is a necessary condition for absorbing infrared radiation. Also there is a change in polarity when infrared radiation is absorbed. A significant number of candidates did refer to this change in polarity, even though they had made no statement about the presence of polar bonds.

(a) Greenhouse gases can absorb infrared radiation. Explain why carbon dioxide absorbs infrared radiation but oxygen cannot.

(2)

Because carbon dioxide has polar bonds, & can thus Stretch. ~~& vibrate~~ And Vibrate: O_2 is a non polar molecule with non polar bonds it Cannot Stretch, & it therefore Cannot absorb infrared Radiation

ResultsPlus
Examiner Comments

This candidate knows part of the answer, but does not state that there is a change in polarity when the molecule vibrates.

(a) Greenhouse gases can absorb infrared radiation. Explain why carbon dioxide absorbs infrared radiation but oxygen cannot.

(2)

Carbon dioxide has ~~is a~~ polar bonds ~~molecule~~ as the dipoles do not cancel out so it can vibrate when absorbing infrared and there is a change in dipole moment. But Oxygen does not have polar bonds and has no change in dipole moment so cannot absorb infrared

ResultsPlus
Examiner Comments

This answer was allowed both marks, for saying that carbon dioxide has polar bonds, and that there is a change of dipole moment when it vibrates. The comment that it has polar bonds as the dipoles do not cancel was not rewarded - it could refer to the different electronegativities of carbon and oxygen.

Question 24 (b) (i)

Aminoethanol is soluble in water because the energy needed to break the hydrogen bonds between water molecules is compensated by energy released when aminoethanol forms hydrogen bonds with water.

All that was required here was to say that aminoethanol can form hydrogen bonds with water. However some candidates said there was hydrogen bonding between aminoethanol molecules which, though true, does not answer the question. Others thought that being a polar molecule was enough to make it water soluble.

(b) A solution of the compound aminoethanol, $H_2NCH_2CH_2OH$, can be used to absorb carbon dioxide.

$$2H_2NCH_2CH_2OH + CO_2 + H_2O \rightleftharpoons (H_3NCH_2CH_2OH)_2CO_3$$

(i) Explain why aminoethanol is soluble in water. **(1)**

* It ~~has~~ can form hydrogen bond with other aminoethanol molecules ~~they~~.

ResultsPlus
Examiner Comments

Formation of hydrogen bonds with water must be stated for the mark.

ResultsPlus
Examiner Tip

When aminoethanol dissolves in water the intermolecular forces between aminoethanol molecules and between water molecules are disrupted, so in your answer it is necessary to refer to both aminoethanol and water.

(b) A solution of the compound aminoethanol, $H_2NCH_2CH_2OH$, can be used to absorb carbon dioxide.

$$2H_2NCH_2CH_2OH + CO_2 + H_2O \rightleftharpoons (H_3NCH_2CH_2OH)_2CO_3$$

(i) Explain why aminoethanol is soluble in water. **(1)**

Aminoethanol consist of hydrogen bonds.

ResultsPlus
Examiner Comments

This statement is meaningless, and just referring to hydrogen bonds does not gain the mark.

ResultsPlus
Examiner Tip

Aminoethanol consists of atoms which are held together by covalent bonds. It is important to express answers carefully. The solubility in water is due to hydrogen bonding, but just referring to hydrogen bonds is not an explanation.

Question 24 (b) (ii)

For this question there were some excellent well-reasoned answers. Many candidates had clearly been taught and had learned the correct phraseology. Answers were usually in terms of the reverse reaction being endothermic, making the forward reaction exothermic. However, vague answers saying that the equilibrium moved to resist the change were also common.

(ii) The position of this equilibrium moves to the left on heating. This frees the captured carbon dioxide for storage. Use this information to decide whether the forward reaction is exothermic or endothermic. Explain your answer.

(2)

The forward reaction is exothermic because increasing temperature would move the position of equilibrium to the endothermic direction and since it moves to the left the reverse reaction must be endo thermic

ResultsPlus

Examiner Comments

This was typical of many of the answers seen and scored both marks.

(ii) The position of this equilibrium moves to the left on heating. This frees the captured carbon dioxide for storage. Use this information to decide whether the forward reaction is exothermic or endothermic. Explain your answer.

(2)

The forward reaction is endothermic, as by Le Chatelier's principle, upon heating an equilibrium will move to the endothermic side in order to cool the system.

ResultsPlus

Examiner Comments

This candidate has not applied Le Chatelier's principle correctly.

ResultsPlus

Examiner Tip

The equilibrium will move to use up the heat supplied. As the equilibrium moves to the left, the reverse reaction is the one using up heat.

Question 24 (c) (i)

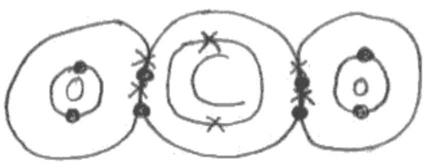
The question did not specify whether the electrons in the inner shells of carbon and oxygen had to be shown. However if the candidate chose to show them they had to be correct. The electrons in the double bonds were often shown correctly, but mistakes were often seen in the numbers of non-bonding electrons in oxygen.

(c) The composition of a sample of natural gas and the melting temperatures of four of its components are shown below.

	Percentage	Melting temperature / K
Methane	95.2	91.1
2-methylpropane	0.8	113.7
Butane	0.9	134.7
Other hydrocarbons	2.4	
Carbon dioxide	0.7	216.5

(i) Draw a dot and cross diagram for carbon dioxide.

(2)



ResultsPlus
Examiner Comments

This candidate has included the inner shell electrons correctly, but has forgotten the two lone pairs on each oxygen atom.

ResultsPlus
Examiner Tip

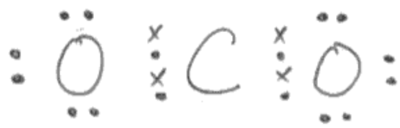
Remember to check the number of non-bonding electrons on each atom, as well as the electrons in the bonds.

(c) The composition of a sample of natural gas and the melting temperatures of four of its components are shown below.

	Percentage	Melting temperature / K
Methane	95.2	91.1
2-methylpropane	0.8	113.7
Butane	0.9	134.7
Other hydrocarbons	2.4	
Carbon dioxide	0.7	216.5

(i) Draw a dot and cross diagram for carbon dioxide.

(2)



Examiner Comments

This mistake occurred quite often. Oxygen was shown with eight electrons in its outer shell before it formed the bonds with carbon.

Examiner Tip

The atomic number tells you the total number of electrons in the atom, not the number in the outer shell.

Question 24 (c) (ii)-(iii)

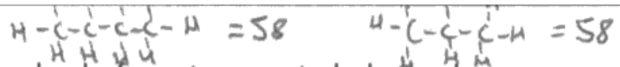
Part (i) of this question was specifically about the different strengths of London forces. This did not stop candidates writing about polar bonds, dipole-dipole interactions, the strength of double bonds and the presence of lone pairs. Many stated that oxygen has more electrons than hydrogen, without making it clear that two oxygens within CO_2 contribute more electrons to the molecule than four hydrogen atoms in methane do. Some candidates calculated the number of electrons in each molecule, but these attempts were often incorrect as they were based on mass numbers instead of atomic numbers.

When contrasting butane and methylpropane, some said that they had the same number of electrons. This is true, but does not answer the question about why their melting temperatures differ. Many wrote about molecules of butane being able to pack more closely, but they did not always associate this with the shape of the molecules or their surface area.

(ii) The London forces between molecules of carbon dioxide are stronger than the London forces between molecules of methane. Suggest a reason for this.

(1)

- there are more electrons in carbon dioxide than methane eg. RMM of CO_2 = 44 , methane = 16



(iii) Use your knowledge of intermolecular forces to suggest why butane has a higher melting temperature than 2-methylpropane.

(2)

- butane has a non branched structure whereas 2-methyl propane has a branched structure, this allows butane molecules to have ~~a~~ stronger intermolecular forces of attraction as the molecules can pack closer together due to unbranched structure
- butane has ~~larger~~ stronger intermolecular forces of attraction, so more energy required to break intermolecular forces of attraction, than [illegible]

ResultsPlus

Examiner Comments

This lost the first mark because the number of electrons given was incorrect, but it scored both marks in (ii).

ResultsPlus

Examiner Tip

When you calculate the number of electrons in a molecule, you need to use the atomic numbers. Methane has 10 electrons and carbon dioxide has 22.

(ii) The London forces between molecules of carbon dioxide are stronger than the London forces between molecules of methane. Suggest a reason for this.

(1)

There are more electrons in carbon dioxide than in methane.

c-c-c-c c-c-c-

(iii) Use your knowledge of intermolecular forces to suggest why butane has a higher melting temperature than 2-methylpropane.

(2)

Straight chain molecules have high melting temperatures than branched molecules because branched molecules do not fit together as well as straight chain molecules so less London forces are present.

ResultsPlus

Examiner Comments

This is an example of an answer which gained all three marks.

Question 24 (d) (i)

Examiners were surprised by the number of wrong answers given for the flame test on magnesium carbonate. Many candidates said that a bright white light would be seen, the observation made when burning the element. "White" was not allowed as the answer here; it had to be clear that magnesium carbonate would not colour a flame. The result for calcium carbonate was better known.

(d) When carbon dioxide dissolves, it may eventually form minerals such as magnesium carbonate and calcium carbonate.

(i) State the results of flame tests carried out on these two minerals.

(2)

Magnesium carbonate .... white

Calcium carbonate .... Brick-red

ResultsPlus
Examiner Comments

This scored the second mark only.

ResultsPlus
Examiner Tip

Remember that if you put a sample of a magnesium compound in a flame, what you will not see is not the same as when you burn a piece of magnesium.

(d) When carbon dioxide dissolves, it may eventually form minerals such as magnesium carbonate and calcium carbonate.

(i) State the results of flame tests carried out on these two minerals.

(2)

Magnesium carbonate .... bright white light flame

Calcium carbonate .... brick red flame

ResultsPlus
Examiner Comments

This also scored the second mark only. A range of colours was allowed for the calcium flame, but red had to be included.

Question 24 (d) (ii)

Many answers to this question suggested a lack of practical experience or knowledge. Suggestions included soaking iron wool in calcium carbonate, heating carbonate solutions in a water bath, measuring the melting points of the carbonates, measuring enthalpy changes and many more unworkable or chemically impossible ideas. Few answers were succinct. Diagrams could be included as an aid to describing the method, but fortunately for the candidates the quality of the diagrams was not marked, and very few diagrams actually enhanced the candidates written responses.

The first mark was for suggesting a suitable method. This could involve collecting the gas evolved, passing the gas into limewater, or setting up an experiment in which change of mass could be measured. However different methods were often combined making the suggestions unworkable, for example measuring the volume of gas after passing it through lime water. Many candidates seemed to think that the first appearance of bubbles when the carbonates were heated indicated thermal decomposition, and had forgotten that expansion of the air in the tube would cause this.

The second mark had to state the measurement which would be made. "Measure the reaction" or even "measure the rate at which the gas is produced" did not score a mark. Measuring the temperature at which the carbonate decomposed was not a practical proposition, especially when no way of detecting the decomposition was suggested.

The most common suggestion for making the comparison fair was to take equal masses of the carbonate, but equal numbers of moles should have been used. Many tried to describe the need for a constant strength of Bunsen flame, but did not score by saying just "use the same bunsen" or "use the same heat". Many candidates wrongly thought that repetition of the experiments produced a fair test.

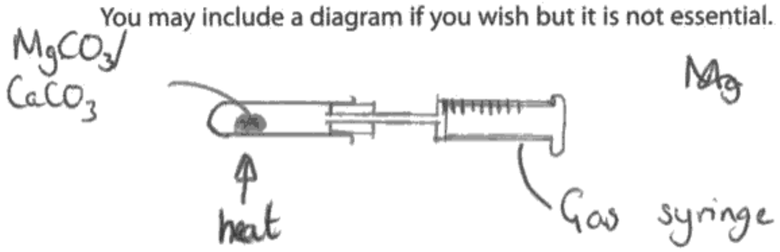
*(ii) Magnesium carbonate and calcium carbonate both undergo thermal decomposition, but they have different stability to heat. The difference in stability to heat can be compared in an experiment.

Suggest how this experiment could be carried out. You should indicate

- how to detect when the thermal decomposition occurs
- the measurement you would make to compare the stability to heat
- how to make the comparison fair.

You may include a diagram if you wish but it is not essential.

(4)



$MgCO_{3(s)} \longrightarrow MgO_{(s)} + CO_{2(g)}$

- As thermal decomposition occurs, CO_2 gas is produced - this is shown by the gas syringe.

-The measurement would be the time taken for a ~~c~~ decided volume of CO_2 gas to produced. -The quicker it happens, the less thermal stability.

Repeat
~~Repeat~~ the experiment three times with the the the same heat, and same quantity of carbonate each time.
Ensure the gas syringe is completely empty after each experiment.

ResultsPlus
Examiner Comments

This answer scored the first two marks, but the description of how to make the comparison fair was not good enough.

ResultsPlus
Examiner Tip

When you repeat an experiment it makes your results more reliable, but it does not make the tests you are doing fair comparisons.

~~Add two seperate test tubes conical flasks add Magnesium Carbonate and Calcium carbonate to~~

Heat in boiling tubes both Magnesium Carbonate + Calcium carbonate. -Time how long it takes for either to show first signs of reaction (decomposition) → ie ~~each~~ any bubbles forming → turning into liquid etc.
To make it fair, use the same bunsen burner, look for similar signs of reactions in both tubes.

ResultsPlus
Examiner Comments

Answers like this did not score. The method for detecting decomposition implies that the solid carbonates will start to bubble. The use of the same Bunsen burner is not good enough for a mark for a fair test.

Question 24 (d) (iii)

Many candidates gained a mark by knowing that calcium carbonate was more stable to heat than magnesium carbonate. After this, marks were often lost because it was not clear that the differences were due to the calcium and magnesium ions. Many answers said that magnesium atoms were smaller than calcium atoms, or just that "magnesium is smaller than calcium" or even "magnesium carbonate is smaller than calcium carbonate". Some of the answers that correctly compared ionic radii and polarising power concluded that magnesium carbonate was more stable because the ions were closer to each other. Some answers were in very general terms, saying that the ionic radius increases and polarising power of a cation decreases going down a Group in the Periodic Table. These ideas had to be clearly applied to the two carbonates in the question to earn full marks.

Very few candidates gave an answer in terms of the energy released on forming the oxide.

*(iii) State and explain which of the two carbonates is more stable to heat.

(3)

Magnesium carbonate is the weaker than calcium carbonate because it is much smaller and so has a high charge density and so weaken the bond and less heat is needed to break the bonding in magensium carbonat

ResultsPlus
Examiner Comments

This candidate is probably thinking along the right lines. There is no clear statement that magnesium carbonate is less stable, though this is implied by saying that less heat is needed to break the bonding so the first mark was allowed.

There is no reference to ions so the second and third marks were not given. "Weakening the bonding" could refer to the bonds in the carbonate ion or to the ionic bonds between the magnesium and the carbonate.

This candidate may have had the right ideas, but they were not expressed clearly enough to get the marks.

*(iii) State and explain which of the two carbonates is more stable to heat.

(3)

Calcium carbonate is more stable to heating. This is because ~~Calcium~~ calcium ions, Ca^{2+} have a larger ionic radius and thus a smaller charge dencity. This ~~make~~ makes Ca^{2+} ions less able to polarise ~~the~~ and distort the electron ~~clould~~ cloud of the carbonate anions. More heat energy is required to decompose calcium carbonate thermally into carbon dioxide and calcium oxide.

ResultsPlus

Examiner Comments

This is an example of a good answer which scored all three marks.

Paper Summary

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

- Reports by examiners almost always advise candidates to read the question carefully, and this one is no exception. Marks are regularly lost because candidates do not actually answer the question which is asked. One example of this was in 24(d)(ii) where candidates discussed the theory without suggesting how to carry out the experiment.
- Candidates often lose marks because their answers are not expressed clearly, and more practice in giving explanations is needed. Answers including the right technical terms cannot be rewarded unless their meaning is clear
- Calculations should also be set out clearly. Candidates should be encouraged to explain what they are doing in numerical work. Many scripts just gave sets of numbers with no explanation in the titration calculation. Use of standard form should also be encouraged, as errors arise in transferring numbers with many zeros at the start, such as 0.000605 in the titration.

Grade Boundaries

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

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