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Examiners' Report
June 2017

IAL Chemistry WCH02 01

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Introduction

This paper was evidently accessible to all candidates as seen by the wide spread of marks and it also served to differentiate effectively between candidates of different levels of ability. There was scope for both the less and the more able to demonstrate their knowledge and understanding. There was no evidence seen that candidates lacked sufficient time to complete the paper. The mean of the multiple choice was just under 14, with questions 16 and 17 proving the most challenging. The questions on the paper were from a wide variety of topics and some novel situations that required candidates to apply their knowledge and understanding.

Question 21 (a)

Although it was generally well understood that the titration results needed to be concordant, many candidates went on to write about the third titration and so lost the mark. It was surprising how many students used words such as close, near, similar or in close agreement instead of concordant and so scored no marks. This serves to emphasise the importance of using correct chemical terminology.

(a) State why it was **not** essential to carry out the third titration.

(1)

The mean titre keeps the same

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Examiner Comments

This is an example of a response which did not score because it does not address the reason why the third titration was unnecessary.

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Examiner Tip

This question includes a good practical tip, namely that if the first two titrations are concordant then there is no need for further titrations which may help candidates when carrying out experiments.

Question 21 (b) (i)

The colour change with starch was not known as much as was expected. Some candidates gave the colour change with indicators such as phenolphthalein. Shades of colours were ignored so references to 'dark' or suchlike for the initial blue colour were not necessary. Candidates should be well aware of the colour changes in titrations and know those changes for all of the respective situations.

(i) State the colour change observed at the end-point with starch.

(1)

From purple to colourless

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Examiner Comments

This is example of an incorrect starting colour and this response did not score.

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Examiner Tip

Learn all of the indicator colour changes and familiarise yourself with them to avoid confusion.

(i) State the colour change observed at the end-point with starch.

(1)

From dark blue to pale yellow

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Examiner Comments

The shading of the initial colour is ignored but the final colour is incorrect and so this response does not score.

Question 21 (b) (ii)

As in the previous question, it was expected that more candidates would be aware of the substance that starch reacts with. Aside from answers containing iodine, there were answers that incorrectly referred to sodium thiosulfate and potassium. Clearly this is an area where centres would benefit from a review with their students.

(ii) Identify the substance in the titration mixture that reacts with starch.

(1)

Iodide ions.

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Examiner Comments

This response illustrates the need to use the correct chemical term because the correct answer is iodine (molecule) and not iodide (ions).

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Examiner Tip

Take care to use the correct species term for the halogens, e.g. use of iodide for iodine is not correct here.

(ii) Identify the substance in the titration mixture that reacts with starch.

(1)

Iodide ions. I_2

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Examiner Comments

This is an example of a response which has two answers. In this particular case one is incorrect and one is correct. The incorrect answer negates the correct one and so this response was given zero.

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Examiner Tip

Never give two answers to one question because an incorrect answer will negate a correct one.

Question 21 (c) (i)–(iv)

Titration calculations continue to serve as effective discriminators and this question produced a wide spread of marks. There was frequent evidence of candidates rounding up values during the steps of calculation, but this should be done at the end of a calculation to avoid introducing a wider degree of uncertainty. Candidates are very good at giving values to the correct number of significant figures but the molar ratio of three moles of iodine to one mole of iodate(V) was often missed. This resulted in a tablet value that should have been nonsensical to candidates seeing as it was larger than the original tablet value but this point was either overlooked or not appreciated. Credit was given in part (iv) for a sensible comment on the suitability of the tablets which enabled many to gain at least one mark. Very few candidates considered the possibility that the breakdown products could themselves be toxic.

(c) The equations for the reactions involved are

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$$

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

(i) Calculate the number of moles of sodium thiosulfate that reacted. **(1)**

= 19.85 × 0.08 / 1000

= 1.191 × 10⁻³ moles.

(ii) Calculate the number of moles of iodine that reacted with the thiosulfate. **(1)**

Mole ratio $2S_2O_3^{2-}$: I_2

2 : 1

= 1.191 × 10⁻³ / 2

= 5.955 × 10⁻⁴ moles.

(iii) Calculate the mass in **milligrams** of potassium iodate(V) in each tablet. Give your answer to **three** significant figures. **(3)**

Mole ration IO_3 : I = 1 : 3

No. of moles IO_3 = 5.955 × 10⁻⁴ / 3 moles

Molar mass of IO_3 = 126.9 + (16×3)

= 174.9

∴ ~~Molar~~ Mass of IO_3 = 174.9 × 5.955 × 10⁻⁴ / 3 × 1000

= ~~0.0347~~ 34.7 mg

(iv) In a radiation emergency, the recommended adult dose is 170 mg of KIO_3 every 24 hours.

Using your result to (c)(iii), suggest whether or not the old tablets of potassium iodate(V) are suitable for use. Justify your answer.

(2)

1 dose provides 34.7mg

so the patient has to consume 5 tablets in 24 hours,

to obtain recommended dose, thus the old tablets are

unsuitable as too less KIO_3 mass in tablet, cannot

reach reccommended dose

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Examiner Comments

Parts (i) and (ii) are correct for both marks.
Part (iii) has an incorrect molar mass value but otherwise the method is correct and so two marks were awarded.
In part (iv) the candidate has correctly worked out the number of tablets that would be required to reach the recommended dose and then stated that these tablets would supply less than they should do. Hence both marks possible were awarded.

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Examiner Tip

Transferred error is applied where possible and so a calculation should always be continued until the end because oftentimes credit can be given for the correct methodology following from an incorrect step.

(c) The equations for the reactions involved are

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$$

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

(i) Calculate the number of moles of sodium thiosulfate that reacted.

(1)

0.0600 × 0.01985 =

0.0019100 mol

(ii) Calculate the number of moles of iodine that reacted with the thiosulfate.

(1)

0.001900 ÷ 2 =

0.000595500 mol

(iii) Calculate the mass in **milligrams** of potassium iodate(V) in each tablet. Give your answer to **three** significant figures.

(3)

0.0005955 x (39.1 + 126.9 + 16 + 16 + 16) =

0.127437

0.127437 x 1000 =

127.437

127 mg

(iv) In a radiation emergency, the recommended adult dose is 170 mg of KIO_3 every 24 hours.

Using your result to (c)(iii), suggest whether or not the old tablets of potassium iodate(V) are suitable for use. Justify your answer.

(2)

They are not suitable, as one tablet has less than the ~~requ~~ recommended dose (only 127 mg). 2 tablets can't be taken at the same time as it would be way over 170 mg (2 tablets → 254 mg)

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Examiner Comments

In part (i) the candidate appears to have copied down the number, 0.001191, incorrectly because the answer to part (ii) is the correct answer in the mark scheme.
The answer in part (iii) is worthy of two marks. The multiplication by the M_r of 214 is correctly carried out and then the value has been multiplied by 1000 to convert to milligrams. However the molar ratio of 3:1 has been omitted and so this mark has been lost.
In parts (iii) and (iv) the candidate seems not to have noted that the stem of the question stated that the tablet originally contained 85mg and so the answer of 127mg cannot be correct because the content should have decreased over time. Hence this made the answer problematic in part (iv) with a tablet value of 127mg but a maximum mark of one was awarded for the suitable comment.
Hence the score for this response is 0 - 1 - 2 - 1.

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Examiner Tip

It is worth double-checking the working and writing down from the calculator to make sure that mistakes such as this are avoided.
Always make a note of the information given in the stem, especially numerical values which are likely to be drawn upon in the subsequent questions.

Question 21 (c) (v)

Many candidates left their answer in cubic decimetres but did not include units and so lost a mark. Additionally, the question asked for a minimum volume that should be added, namely a suitable volume in excess and this was a very effective discriminator for the stronger candidates. It must be stressed that an awareness of the practical equipment that would be used was required and so a volume of only 13cm^3 from a calculated volume of 12.9 cm^3 would not be appropriate because a measuring cylinder would not be able to able to read to this value. Likewise a volume of 13.5cm^3 would also be inappropriate.

Candidates may have benefited from reading the question more thoroughly as once the calculation was done, many simply moved on. This prompts a reminder that in the pressure of the exam setting, candidates should pause and make sure that all of the question has been answered.

(v) The experiment was repeated with a different batch of tablets. The conical flask contained 2.15×10^{-4} mol of potassium iodate(V).

Calculate the minimum volume of 0.100 mol dm^{-3} hydrochloric acid that should be added to ensure that all of the potassium iodate(V) is converted to iodine and hence suggest an appropriate volume to use.

(3)

mole of HCl $= 2.15 \times 10^{-4} \times 6$

$= 1.29 \times 10^{-3}$ mol

volume (minimum) $= \dfrac{1.29 \times 10^{-3}}{0.1}$

$= 0.0129$ dm^3

$= 12.9$ cm^3

∴ A volume of 19 cm^3 may be suitable

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Examiner Comments

This is an example of a nicely laid-out response which scored full marks. The volume of 19cm^3 is a rather unusual value but was within the range that would work and be appropriate thus credit was given.

Question 21 (d) (i)

This was a high scoring question which allowed candidates to demonstrate their understanding. However one relatively common mistake was to multiply the oxidation number of the iodide ion by the number of moles but this is incorrect. The oxidation number of the individual atom in the species is always required.

The spelling of disproportionation clearly needs to be practised and, although some leniency was given, at times the attempt was just too poor.

(d) Potassium iodate(V) can be produced from iodine and potassium hydroxide.

(i) Give the oxidation numbers of iodine in the iodine-containing species in the following equation. Hence classify the reaction.

(2)

$$6KOH + 3I_2 \rightarrow 5KI + KIO_3 + 3H_2O$$

	$3I_2$	$5KI$	KIO_3
Oxidation Number	0	-5 ~~-1~~	+5

Type of reaction: Disproportionation reaction

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Examiner Comments

An example where the correct value of -1 has sadly been crossed out and replaced with an incorrect one.

ResultsPlus
Examiner Tip

Remember that the number in front of the species is only used as an aid when balancing equations but is never used to multiply the oxidation number if the value of the element in the species is required.

Question 21 (d) (ii)

A significant number of candidates did not understand this question because a definition of disproportionation was given. The question clearly asks for the 'conditions' that would be expected for this reaction. The similar reaction with chloride requires heat and concentrated alkali but due to the more reactive nature of iodide, only heat was required. Some examples of wrong conditions that examiners commented on were: use of an alcoholic solvent and UV light. One response even suggested that the conditions needed were 'acid' but this is forgetting that alkaline conditions are necessary for this reaction.

(ii) State the conditions necessary for this reaction to occur.

(1)

~~room temperature and normal pressure~~ both reduction and oxidation reaction has taken place

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Examiner Comments

An example of an incorrect attempt to define disproportionation. For the definition there would need to be reference to the element but regardless of this the question requires conditions and so no credit was given.

(ii) State the conditions necessary for this reaction to occur.

(1)

~~Star~~ The KOH should be dissolved in ethanol (The solution should be alcoholic).

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Examiner Comments

An example of incorrect conditions given. Alcoholic alkali is used with halogenoalkanes to produce alkenes which is an entirely different topic.

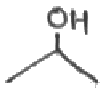
Question 22 (a)

The drawing of skeletal formulae continues to prove challenging for many candidates and so it is always wise for centres to spend some considerable time practising drawing such. There were the usual errors such as drawing formulae with the wrong number of carbon atoms or drawing the wrong type of formulae. In addition there seems to be an increase in the number of candidates writing a truncated form of the name of molecules, for example prop-1-ol. This practice needs to be avoided because it is ambiguous since either an 'an' or an 'en' could be in the stem of the name. In addition propanol is not equivalent to propan-1-ol. Almost all of the classifications given were correct, with occasionally tertiary given instead of secondary.

(a) There are two alcohol structural isomers with the molecular formula, C_3H_8O.

Give the **skeletal** formula of these isomers, their systematic names and the classification of the type of alcohol in each case.

(3)

Skeletal formula	Name	Classification
	Propan-2-ol	Secondary
	Propan-1-ol	Primary

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Examiner Comments

Note the illustration in the second row of how it can be easy to get skeletal formulae incorrect. This candidate has given the name and classification of propan-1-ol but drawn the skeletal formula for an alcohol with only two carbons. This response was awarded 2 marks.

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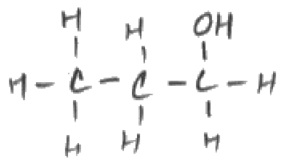
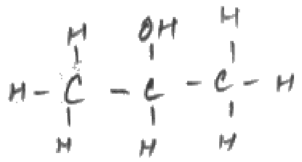
Examiner Tip

Remember that each apex is a carbon atom.

(a) There are two alcohol structural isomers with the molecular formula, C_3H_8O.

Give the **skeletal** formula of these isomers, their systematic names and the classification of the type of alcohol in each case.

(3)

Skeletal formula	Name	Classification
	Propane-1-ol	Primary alcohol
	Propane-2-ol	Secondary alcohol

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Examiner Comments

This is an example of the candidate either not understanding what skeletal formulae are or not being confident in drawing such and so doing displayed formulae instead. There was no credit given for displayed formulae and so this response was awarded two marks.

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Examiner Tip

Always answer the question set so if skeletal formulae are requested then give skeletal formulae.

Question 22 (b)

The equation in part (i) was quite well known, with the balancing of the species occasionally proving problematic for some candidates.

The description required in part (ii) was not always so well done with many statements made about the equipment without reference to how the equipment would actually ensure that the ethanal would be further oxidised.

Candidates may have benefited from reading the question more thoroughly as many did not give sufficient detail. The most common omissions were oxygen lone pairs of electrons, or if they were drawn it was not uncommon for them to be incorrectly drawn outside of the hydrogen bond. The linear nature of the hydrogen bond and the clear drawing of such is a useful indicator of how well a candidate is doing. This type of diagram is always worth centres practising.

The mark in part (iv) was frequently awarded as the majority of candidates understood this well.

(i) Complete the ionic half-equation for the reduction of the dichromate(VI) ions to chromium(III) ions. State symbols are not required.

(2)

$Cr_2O_7^{2-}$ + 14 H^+ + 6e$^-$ → 2Cr^{3+} + 7H_2O

(ii) Describe how the reflux apparatus ensures that any ethanal initially produced is further oxidised to ethanoic acid.

(1)

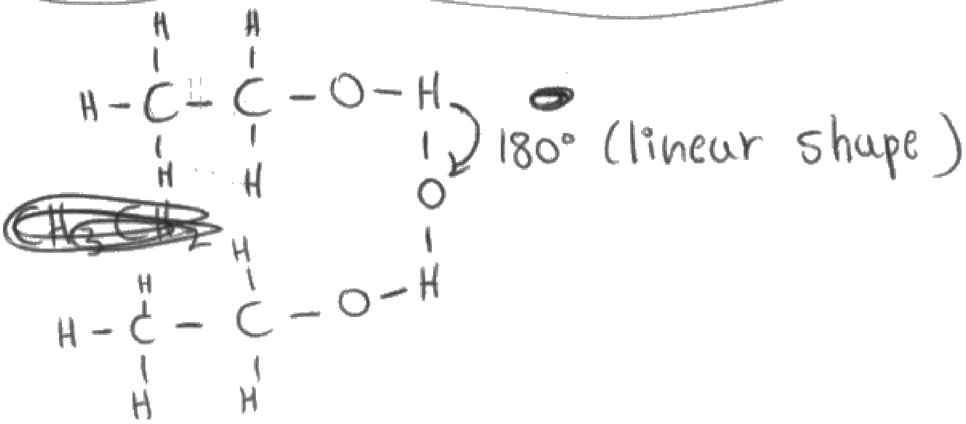
In the liebig condenser

(iii) The distillation apparatus effectively separates ethanal from ethanol because of the large difference in boiling temperatures, which is a result of the hydrogen bonding between the molecules in ethanol.

Compound	Boiling temperature / °C
Ethanol, CH_3CH_2OH	79
Ethanal, CH_3CHO	21

Draw a hydrogen bond between two ethanol molecules. Clearly indicate any relevant dipoles and lone pairs of electrons. Label the bond angle about the hydrogen involved in the hydrogen bond and give its value.

(3)



(iv) Explain why hydrogen bonds do **not** form between ethanal molecules.

(1)

Because there isn't an O-H bond in ethanal so water can't form a hydrogen bond.

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Examiner Comments

The species and balancing given in part (i) are correct for two marks.
In part (ii) the response does not describe how the ethanal produced is further oxidised but states that something happens in a piece of laboratory equipment.
The diagram in part (iii) is not good. There is an extra oxygen atom which is bridging the two ethanol molecules and the hydrogen atoms of the OH groups have two covalent bonds. In addition the angle is labelling that between two atoms and not a bond angle. No credit was given.
The answer to part (iv) is a bit messy but it does make the correct point that ethanal does not have an OH group, only C=O, and so cannot form hydrogen bonds. The reference to water was ignored because it does not negate the correct observation that hydrogen bonding, with water or with another ethanal molecule, cannot form because there is no OH group.

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Examiner Tip

Hydrogen bonding diagrams are an important part of chemistry as they help to illustrate many properties and so time spent practising drawing them is well worth the investment.

(i) Complete the ionic half-equation for the reduction of the dichromate(VI) ions to chromium(III) ions. State symbols are not required.

(2)

$Cr_2O_7^{2-}$ + 14 H^+ + 6 e^- → $2Cr^{3+}$ + $7H_2O$

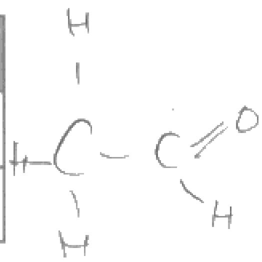
(ii) Describe how the reflux apparatus ensures that any ethanal initially produced is further oxidised to ethanoic acid.

(1)

The ethanal formed initially will be condensed in Liebig condenser and returns back into the flask for further oxidation into ethanoic acid

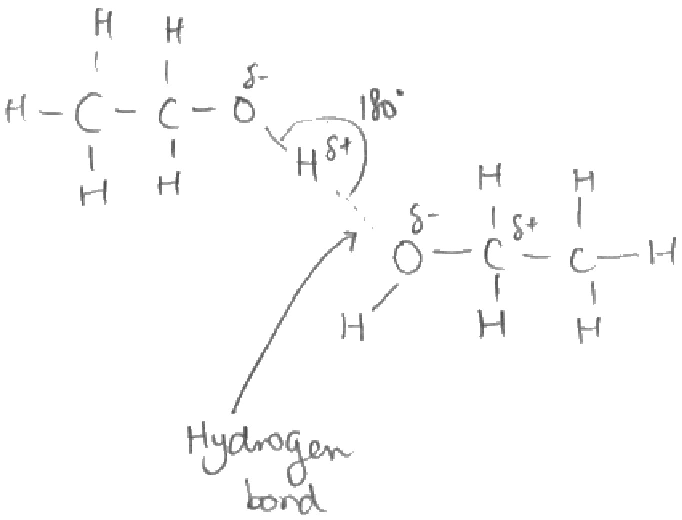
(iii) The distillation apparatus effectively separates ethanal from ethanol because of the large difference in boiling temperatures, which is a result of the hydrogen bonding between the molecules in ethanol.

Compound	Boiling temperature / °C
Ethanol, CH_3CH_2OH	79
Ethanal, CH_3CHO	21



Draw a hydrogen bond between two ethanol molecules. Clearly indicate any relevant dipoles and lone pairs of electrons. Label the bond angle about the hydrogen involved in the hydrogen bond and give its value.

(3)



Bond angle is 180°

(iv) Explain why hydrogen bonds do **not** form between ethanal molecules.

(1)

There are not enough lone pairs ~~for~~ to form an area of higher electron density between the O (on the C=O) and the H

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Examiner Comments

The species and balancing of the equation in part (i) are correct for two marks. The response in part (ii) correctly describes the condensing of the ethanal and subsequent return to the flask for further oxidation and so is worthy of the mark. The hydrogen bonding diagram was given two of the three marks available. Although the dipole given on the ethanol molecule to the bottom right is between the carbon and oxygen instead of the hydrogen and oxygen of the double bond, there is a correct dipole on the other ethanol molecule O-H group and so in this instance the dipole mark was awarded. However there is no lone pair of electrons drawn on the oxygen which are involved in the hydrogen bond and so this mark was not given. The hydrogen bond is correctly drawn linear for the O ------ H— O shape and the bond angle of 180 degrees is also correctly indicated.
The comment in part (iv) is incorrect because the oxygen atom of a carbonyl group has the same number of lone pairs of electrons as that of a hydroxyl group.

Question 22 (c) (i)

The equation for the reaction of phosphorus(V) chloride with an alcohol is well-known and it was pleasing to see so many correct responses.

(i) Write the equation for the reaction between methanol, CH_3OH, and phosphorus(V) chloride, PCl_5.

(1)

$$CH_3OH_{(l)} + PCl_{5(aq)} \rightarrow ClCH_{3(l)} + PCl_{3(g)} + HCl_{(aq)} + \frac{1}{2}O_{2(g)}$$

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Examiner Comments

An equation which correctly balances for atoms but unfortunately is incorrect.

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Examiner Tip

Learn the correct equation

Question 22 (c) (ii)

A similarly good performance by candidates on the experimental observation from the use of phosphorus(V) chloride to that of the equation. This is clearly an area of chemistry which is understood well.

(ii) State the experimental observation from this reaction.

(1)

Steamy fumes of HCl.

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Examiner Comments

The question merely asks for the experimental observation and not for the identity of the substance responsible. If the substance is given then it must be correct. In this instance the comment is correct and so the mark was awarded.

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Examiner Tip

Save time by just answering the question set and do not give additional information that may negate a correct answer.

Question 22 (c) (iii)

The general understanding of the reducing and oxidising power of the halogens was understood. The best candidates gave full descriptions with balanced equations to illustrate their points. The marking point which was seen least often was the reaction of HCl with ethanol to produce chloroethane which should have been evident from the wording of the question.

*(iii) Chloroethane can be made from a mixture of ethanol, potassium chloride and concentrated sulfuric acid. Explain why chloroethane can be made in this way, but iodoethane cannot be made from a similar mixture using potassium iodide instead of potassium chloride.

You may use equations to support your explanation.

(3)

① $KCl + H_2SO_4 \rightarrow KHSO_4 + HCl$

② $KI + H_2SO_4 \rightarrow KHSO_4 + HI$

~~$2HI + H_2SO_4 \rightarrow I_2 + H_2S + H_2O$~~

③ $8HI + H_2SO_4 \rightarrow 4I_2 + H_2S + 4H_2O$

Cl^- are weak reducing agents and undergoes displacement reaction with concentrated H_2SO_4. ~~I~~ The Cl^- from HCl can act as a nucleophile to form chloroethane through substitution. I^- are strong reducing agents and undergoes oxidation when reacted with concentrated H_2SO_4. most of the iodide ions are oxidized into iodine. Hence no iodide ions left to act as a nucleophile. When HI is formed, it gets further oxidized to iodine by H_2SO_4.

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Examiner Comments

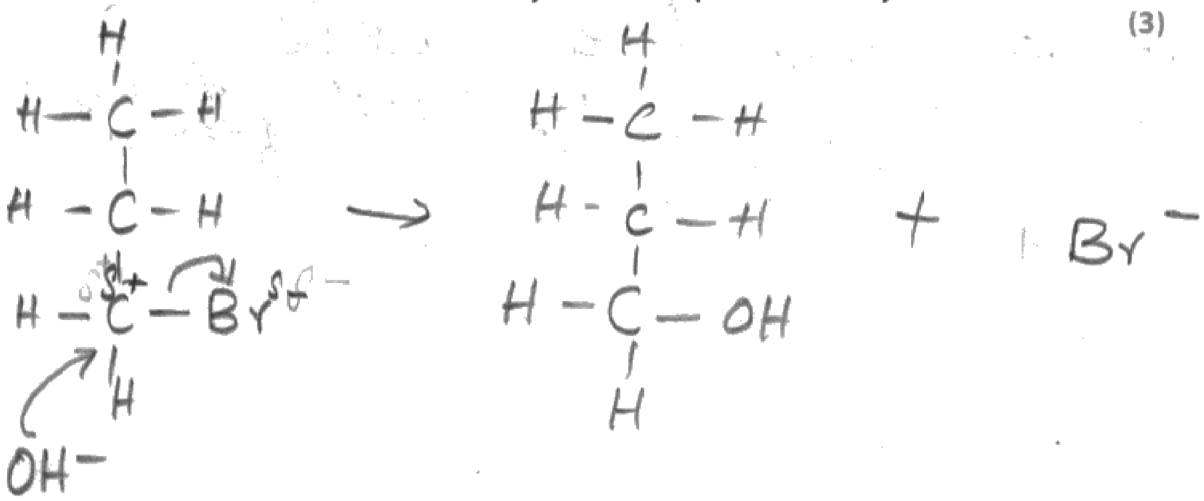
This response does not give the equation for the reaction of HCl with ethanol to form chloroethane but does make the other three marking points available from the mark scheme and so does score all three marks. There is an equation to show the formation of HCl and then there is an equation to show how the iodide ions are oxidised to iodine and that the sulfur in sulfate ions is reduced to sulfur in hydrogen sulfide. There is a lot of good chemistry here which is worthy of credit.

Question 22 (d) (i)

The majority of mechanisms seen were of a high standard with great care taken to give the details required in the question. Those candidates that were more casual in their drawing of the mechanism tended to lose marks for omitting dipoles or lone pairs, or drawing the curly arrow from the hydroxide ion to a bond rather than the carbon atom with the delta-positive charge. Occasionally the charge was missing on the hydroxide. All of these observations stress the need for candidates to double-check their work. It is worth reminding centres and candidates that the difference between S_N1 and S_N2 is an A2 topic and would not be required on an AS paper. Transition states were ignored.

(i) Draw the mechanism for this reaction with 1-bromopropane. Show the lone pair involved in the mechanism and any relevant dipoles and curly arrows.

(3)



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Examiner Comments

The question specifically requires three key things, namely the lone pair, relevant dipoles and curly arrows. In this response the lone pair is absent and so one mark is lost. It is also rather ambiguous as to whether the curly arrow from the hydroxide is going towards the C-H bond or, as it should be, towards the delta-positive carbon. Greater attention to details such as these are advisable.

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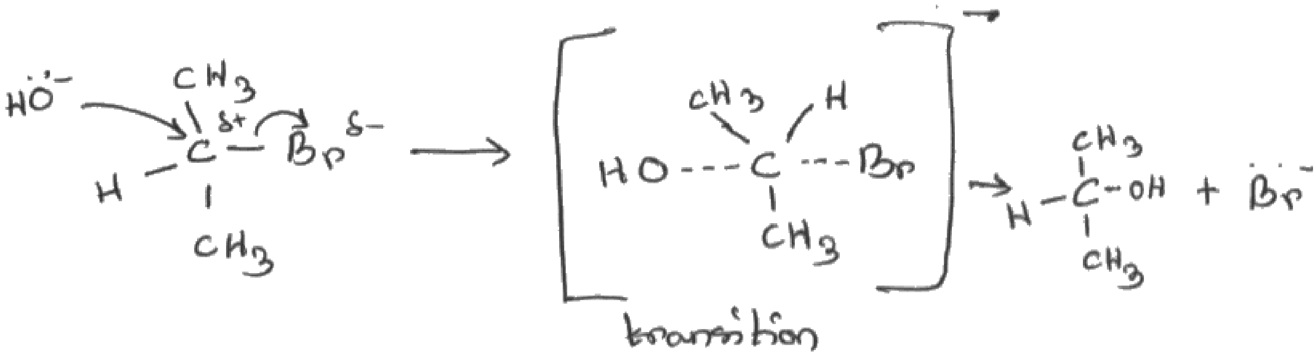
Examiner Tip

Double-check that all of the details required in the question are given so that all of the marks achievable are addressed.

(i) Draw the mechanism for this reaction with 1-bromopropane. Show the lone pair involved in the mechanism and any relevant dipoles and curly arrows.

(3)



C_nH_{2n}

C_3H_6

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Examiner Comments

This response is one of the examples where the mechanism has been correctly drawn but unfortunately the wrong starting substance has been used. In this particular example 2-bromopropane has been used instead of 1-bromopropane. An otherwise correctly drawn mechanism such as this was penalised by one mark so that two marks overall were scored.

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Examiner Tip

Make sure that the correct substance is used in the answer to ensure that all available marks can be awarded.

Question 22 (d) (ii)

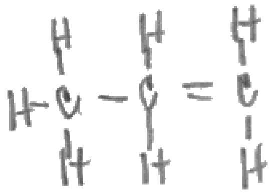
The name of the reaction of a halogenoalkane with alcoholic alkali was answered well and for the most part so were the displayed formulae of the product of this reaction. The main error was giving one of the carbon atoms in the double bond too many bonds to hydrogen atoms.

(ii) The reaction of 1-bromopropane with concentrated alcoholic alkali forms a different organic product. Name the type of reaction and give the **displayed** formula of the product.

(2)

Name of reaction Elimination

Displayed formula of product



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Examiner Comments

An example of a response with a pentavalent carbon atom.

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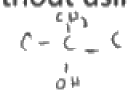
Examiner Tip

When drawing displayed formulae, remember the basics of the number of bonds that each element can form.

Question 22 (e)

The specification clearly lists the reactions of alcohols that candidates are required to know and the prevention of the reaction with phosphorus(V) chloride made many candidates struggle which suggests that the other reactions had not been learnt. There was a tendency for a sizeable number of candidates to suggest use of acidified dichromate(VI) but of course this would not work with the tertiary alcohol in the question. The reaction of alcohols with sodium and the observation of effervescence or bubbles or fizzing was the expected answer and centres should reinforce this reaction.

(e) How would you test for the OH group in 2-methylpropan-2-ol without using phosphorus(V) chloride?



Name the reagent and state the observation for a positive test.

(2)

Add $K_2Cr_2O_7$ and H_2SO_4 to 2-methylpropan-2-ol

~~No~~ Observation:- No colour change occurs, showing that 2-methylpropan-2-ol is a tertiary alcohol ~~as~~ and all alcohols have OH group.

ResultsPlus

Examiner Comments

A somewhat unusual response because this candidate clearly appreciates that the alcohol in the question is a tertiary alcohol and so is resistant to oxidation. However the question specifically requires a "positive test" and so the candidate has not answered the question set. No credit was given for this.

ResultsPlus

Examiner Tip

Candidates would benefit from reading the question more thoroughly to ensure they are answering the question set.

Question 23 (a) (i)

It was pleasing to see that this novel equation was exceptionally well done and showed that candidates have been well-taught to write balanced equations drawing on the information provided and from their subject knowledge.

(a) (i) Write the equation for the formation of boron nitride from boric acid, H_3BO_3, and ammonia.

State symbols are not required.

(1)

$H_3BO_3 + NH_3 \longrightarrow BN + 3H_2O$

ResultsPlus
Examiner Comments

One of the many correctly drawn equations with the correct formula for ammonia and balancing of the equation.

Question 23 (a) (ii)

Many candidates seemed not to appreciate that the unreactive nature of the nitrogen gas in the air around us means that it can be used to provide an atmosphere for reactions such as this.

(ii) Suggest why this reaction is carried out in an atmosphere of nitrogen.

(1)

Because ammonia contains nitrogen which is the most abundant material in air

ResultsPlus
Examiner Comments

It would appear that this candidate has misunderstood the question and is under the impression that the nitrogen for the boron nitride comes from the atmosphere rather than ammonia. This is despite the previous question requiring the equation for the reaction between only boric acid and ammonia. It is worth reinforcing that questions in the same part (a) or (b) etc do follow on from each other.

ResultsPlus
Examiner Tip

Remember to check previous questions to see if any help or direction on the answer needed can be seen.

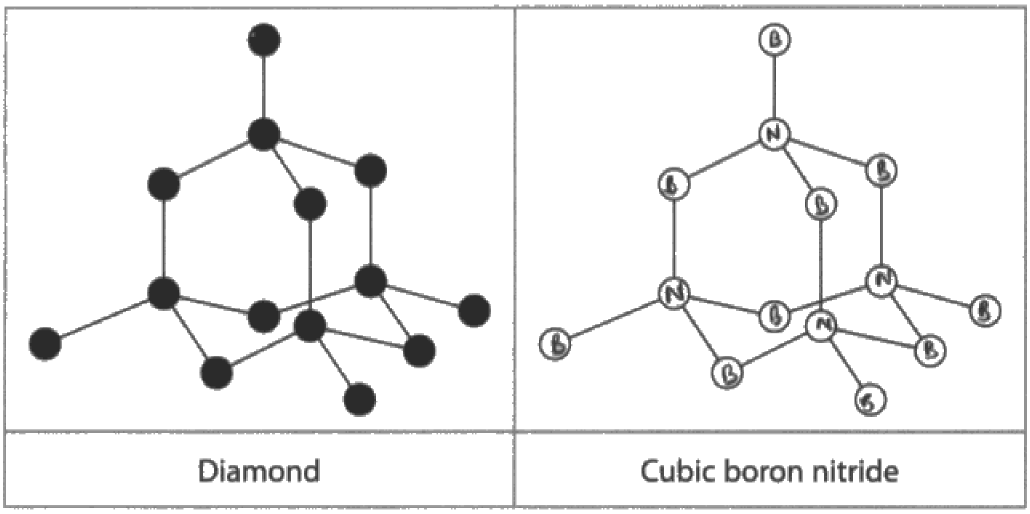
Question 23 (b) (i)

Unfortunately there were many blank responses to this question regardless of the overall ability of the candidate as seen on the rest of the script. Candidates seemed to skip the first part of the question and went straight to answering part (ii). It would be beneficial for candidates to ensure that all parts of a question are addressed.

(i) In the left hand box, the diagram shows a section of the diamond structure, where each black circle represents a carbon atom.

In the right hand box label all the nitrogen and boron atoms in the diagram of cubic boron nitride.

(1)



ResultsPlus
Examiner Comments

An example of a suitably labelled diagram. There is no key provided for the symbols but in this case there is no ambiguity. The circles are correctly labelled alternately with N and B.

ResultsPlus
Examiner Tip

A key for the meaning of symbols used is always advisable.

Question 23 (b) (ii)

The shape and bond angle were largely done correctly, but the wrong angle for the tetrahedral shape was occasionally seen.

The electron repulsion theory is a chemical theory that is clearly well-known and was applied very well by most candidates. There was a tendency for candidates to omit reference to 'electron pairs' and use the term 'bond pairs' instead. It's always advisable that this is the application of the "electron pair" repulsion theory and so reference to electrons should be made. Candidates would have benefited from selecting from their knowledge base what is required for a particular topic as statements such as "lone pairs repel more than bonded pairs" were frequently seen but were not needed for this question, because by the candidates' own admission, there were no lone pairs of electrons!

(ii) State the bond angle and shape around the carbon atoms in diamond and fully justify your answer.

(4)

Bond angle 109.5° Shape tetrahedral

Justification There are four regions of electron density with no lone pairs.

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Examiner Comments

The bond angle and shape are both correct for two marks. This candidate has started their justification correctly by stating that there are four regions of electron density or four bonded pairs which is worthy of credit. However this an insufficient justification because how does the presence of four areas of electron density result in the shape and bond angle? Reference to the repulsion of the electron pairs is required for the fourth mark.

Question 23 (c) (i)

This was one of the more challenging questions on the paper and aimed at the higher-performing candidates although it did allow opportunity for all candidates to gain some credit and so was a very effective discriminator.

There were two aspects to the question, namely temperature and pressure. The answers with respect to temperature were generally done the best. Many candidates appreciated that the forward reaction was endothermic but needed to state that as a consequence of high temperatures the equilibrium position would shift to the right. Only the more able candidates appreciated the significance of the very low enthalpy change quoted such that this would mean that only very high temperatures would have any significant effect on the equilibrium. The most common error candidates made when discussing the effect of pressure was to refer to an increase in rate and to miss that the second piece of information provided in the question after the enthalpy change was the densities of diamond and graphite. The effect of a high pressure would be to force the carbon atoms closer together, i.e. to make the substance more dense and hence towards diamond formation. Only the more astute candidates appreciated this point. The other common error was to refer to the equilibrium moving to the side with more moles of gas but this is irrelevant with two giant structures such as diamond and graphite. Here candidates would have benefited from selecting from their knowledge base what is required for the particular question as opposed to everything about the topic in general.

*(i) Suggest why a very high temperature and high pressure are needed to convert graphite to diamond.

(4)

The carbon-carbon bonds in graphite are strong covalent bonds so they require lots of energy to break. The energy comes from high temperature. The high pressure is to ensure that diamond is formed instead of graphite. This is because of diamond's higher density. The higher pressure causes higher yield of diamond.

ResultsPlus

Examiner Comments

This response has an alternative approach to the effect of temperature and one mark was awarded for the reference to the need for a high temperature to break the strong carbon-carbon bonds. In addition one mark was awarded for reference to the greater density of diamond and thus the increase in yield when high pressure is applied, inferring a shift in the equilibrium to the right. This inference is arguable and serves to illustrate the challenging nature of judgement required when marking questions such as these.

Question 23 (c) (ii)

The definition of a catalyst was well-known and many candidates scored full marks. However at times some candidates referred to the increase in energy of particles/molecules which is not correct when considering the effect of a catalyst.

(ii) The use of a catalyst in the conversion of graphite to diamond has been reported. Describe how the addition of a catalyst can lower the temperature required for a reaction.

(3)

The Catalyst provides an alternative route with a lower activation energy for the compound.

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Examiner Comments

This is a response which makes two clear points, namely that a catalyst will lower the activation energy and that this will be achieved by the provision of an alternative reaction pathway, thus scoring two marks. The third mark was for reference to the increase in proportion of particles/molecules which will then have or exceed the activation energy. The number of marks for this question and the number of lines provided for the answer should have suggested that more detail was required than was given in this response.

ResultsPlus

Examiner Tip

In order to maximise the score always make sure that the number of points made equals the number of marks available for the question.

Question 23 (d)

Approximately 70% of candidates were correctly able to identify either carbon dioxide or carbon monoxide as one of the combustion products. A small minority of candidates suggested substances such as hydrogen which possibly shows lack of chemical knowledge and understanding.

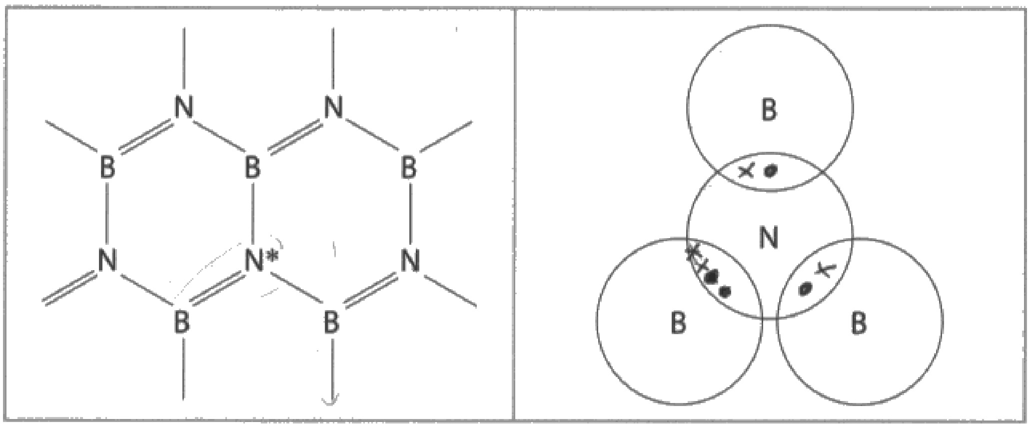
Question 23 (e) (i)

This question proved to be a good discriminator among the top scoring candidates because the only way to correctly draw the dot and cross diagram was to include a dative covalent bond between the nitrogen and one of the boron atoms. This bond could have been either as part of the double bond or as one of the single bonds. It was not uncommon for the wrong number of electrons to be given either for boron or for nitrogen so that the diagram 'worked' but obviously this is not appropriate.

(e) The structure of hexagonal boron nitride corresponds to that of graphite.

(i) The simplified diagram in the left hand box shows the bonding in hexagonal boron nitride.
In the right hand box, complete the dot and cross diagram showing only the electrons around the nitrogen atom which is labelled with an asterisk (*).
Use (×) for the nitrogen electrons and (•) for the boron electrons.

(1)



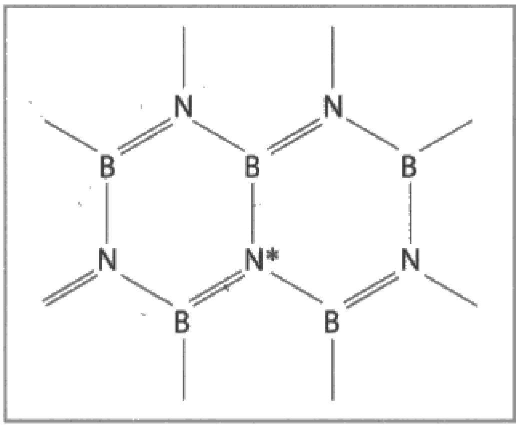
ResultsPlus
Examiner Comments

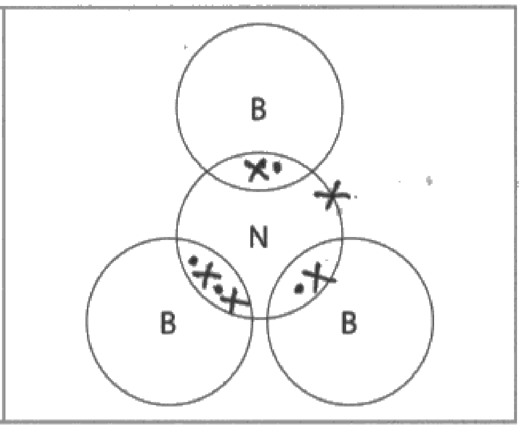
Although there are no electrons outside the overlapping areas, and nitrogen has a total of 8 electrons, only four crosses are shown for the nitrogen electrons but of course there should be 5.

(e) The structure of hexagonal boron nitride corresponds to that of graphite.

(i) The simplified diagram in the left hand box shows the bonding in hexagonal boron nitride.
In the right hand box, complete the dot and cross diagram showing only the electrons around the nitrogen atom which is labelled with an asterisk (*).
Use (×) for the nitrogen electrons and (•) for the boron electrons.

(1)





ResultsPlus
Examiner Comments

This response did not score because of the lone electron in the outer shell of the central nitrogen atom which means that nitrogen has nine electrons in its outer shell. Elements of period 2 cannot 'expand their octet' because the 3d orbitals are unavailable.

ResultsPlus
Examiner Tip

Remember the possibility of dative covalent bonding when completing dot and cross diagrams.

Question 23 (e) (ii)

This should have been a straightforward question for most candidates and yet it provided a wide spread of marks and the responses reflected some points which centres and candidates need to address. Candidates should not be using the term ‘free electrons’: the appropriate term is ‘delocalised electrons’.

At least one mark will be lost for the use of the wrong term. The understanding of the term 'delocalised' also needs to be clarified by centres because some candidates incorrectly asserted that boron nitride was a non-conductor because its delocalised electrons were unable to move. Candidates should have realised from earlier questions that boron nitride does not have delocalised electrons but that the electrons are localised in bonds which results in non-conduction. In addition some candidates did not state the actual number of bonds that each carbon has in graphite, and simply stated that there are delocalised electrons. This detail was required for one of the marks.

*(ii) Describe how each carbon atom is bonded in the graphite structure and hence explain why graphite is a good conductor of electricity. Suggest why hexagonal boron nitride is an electrical insulator.

(3)

There is covalent bond between C-C in the graphite structure and there is a free delocalised electrons which conduct electrisity.
The hexagonal boron nitride is an electical isulator due to the less in the free electrons

ResultsPlus
Examiner Comments

The written English in this response is not good but can be understood. Like many other candidates, this candidate refers to a single delocalised electron which is a concern for the perception of the graphite structure but was not penalised on this occasion. The number of carbon-carbon bonds for each carbon atom is not stated and the comment about boron nitride is insufficient. Hence this response scored one mark.

*(ii) Describe how each carbon atom is bonded in the graphite structure and hence explain why graphite is a good conductor of electricity. Suggest why hexagonal boron nitride is an electrical insulator.

(3)

Each carbon atom ~~f~~ bonds with three adjacent carbon atoms with its three valence electrons. The fourth electron is unbonded which is free to move. Thus it can conduct electricity.

In hexagonal boron nitride there are no unbonded ~~f~~ electrons which can move freely. So it can't conduct electricity.

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Examiner Comments

An example of a response which does not use the term 'delocalised electrons'. The term '"free to move" is not equivalent. Hence this response scored 2 marks.

ResultsPlus

Examiner Tip

Use appropriate terminology for A level and not that which might be suitable for GCSE.

Question 23 (e) (iii)

Only a small minority were unable to name the intermolecular force correctly but thereafter only about half of the candidates were able to gain credit for an explanation for how London forces arise. The most common omission was that the candidate did not explain how the momentary imbalance in electron density results in a temporary dipole. The simple reference to "instantaneous dipole-induced dipole" did not score both additional marks. At times the abbreviation IMF was seen but this is not a universally accepted abbreviation and so should only be used if an explanation of its meaning is given.

(iii) Graphite and the hexagonal boron nitride are both used as lubricants because of the weak intermolecular forces between the layers of hexagonal rings. Identify these intermolecular forces and describe how they arise.

(3)

> Both have London force or Vand der waals ~~force~~ they have an unequal electron distribution.
> Both element have side-branched chains making the melting point lower.

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Examiner Comments

One mark was awarded for the naming of the intermolecular force.
The statement that there is an unequal electron distribution was insufficient to score because this is true of a permanent dipole.

(iii) Graphite and the hexagonal boron nitride are both used as lubricants because of the weak intermolecular forces between the layers of hexagonal rings. Identify these intermolecular forces and describe how they arise.

(3)

These forces are known as London forces. Temporary asymmetric distribution of electrons produce instantaneous dipoles. These ~~dipoles~~ dipoles produce induced dipoles in the ~~ne~~ ~~neighbo~~ adjacent molecules.

ResultsPlus

Examiner Comments

An excellent answer that the candidate and their teacher can be proud of.

Paper Summary

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

- Read the question again after it has been answered to make sure that all of the points required have been made. This includes the information in the stem which may include relevant details that are required to answer the question effectively;
- Use the correct chemical terminology such as delocalised electrons, and in the appropriate places;
- Avoid giving more than one answer to a question as an incorrect response can negate a correct one;
- Always check calculations several times because it is easy to make an error when copying down a value from a calculator. Check that the appropriate number of significant figures has been used for the final value, that rounding up has not been done during a calculation but only at the end and that the final value is the one that directly answers the question;
- Likewise check the formulae written so that errors such as pentavalent carbons atoms are avoided and that skeletal formulae have the correct number of carbon atoms;
- Do not use non-standard abbreviations such as IMF without giving an explanation of their meaning;
- Make sure that all of the questions are answered, including all sub-parts;
- Practise the spelling of such terms as disproportionation;
- Chemistry is a practical subject and carrying out experiments will undoubtedly help you in your understanding and grasp of this subject.

Grade Boundaries

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