GCE

Rewarding Learning

CCEA GCE AS
Exemplifying Examination Performance

Chemistry

This is an exemplification of candidates' performance in GCE AS examinations (Summer 2017) to support the teaching and learning of the Chemistry specification.

EXEMPLIFYING EXAMINATION PERFORMANCE

GCE Chemistry

Introduction

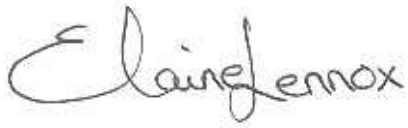
These materials illustrate aspects of performance from the 2017 summer AS examination series of CCEA's revised GCE Specification in 2016.

Students' grade A responses are reproduced verbatim and are accompanied by commentaries written by senior examiners. The commentaries draw attention to the strengths of the students' responses and indicate, where appropriate, deficiencies and how improvements could be made.

It is intended that the materials should provide a benchmark of candidate performance and help teachers and students to raise standards.

For further details of our support package, please visit our website at www.ccea.org.uk

Best wishes



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GCE: AS CHEMISTRY

SCH12 Basic Concepts in Physical and Inorganic Chemistry

Grade: A Exemplar

Section B

Answer **all five** questions in the spaces provided.

Q11 Sulfate, hydrogensulfate and thiosulfate ions are formed when sulfuric and thiosulfuric acids ionise.

Q11a(i) Write the equation for the complete ionisation of thiosulfuric acid. [2]

Student's response

$H_4SO_4 \rightarrow 5O_4^{2-} + 2H_2^+$

Examiner's comments

This question was very poorly answered even by Grade A candidates. One mark was awarded for the equation and one mark for balancing the equation. Because the responses provided by candidates were of a poor standard the mark scheme was adjusted allowing candidates who provided the correct formula of thiosulfuric acid to attain one mark.
Marks awarded 0

Q11a(ii) Write the formula for the hydrogensulfate ion. [1]

Student's response

HSO_4^-

Examiner's comments

Generally this question was well answered by most Grade A students. If the mark was lost it was for providing an incorrect charge for the hydrogensulfate ion, usually 2-.
Marks awarded 1

Q11b(i) Write the formula for ammonium sulfate. [1]

Student's response

$(NH_4)_2SO_4$

Examiner's comments

The formula provided for ammonium sulfate was generally well answered by most Grade A candidates.
Marks awarded 1

Q11b(ii) Describe the bonding in ammonium sulfate. [2]

Student's response

The molecules are covalently bonded with a ratio of two ammonium ions per one sulphate ion.

Examiner's comments

This question proved to be very challenging. Many candidates incorrectly described the bonding between the ions as covalent. There appeared to be a confusion between the bonding inside each ion and the bonding between ions. As is illustrated in this script, candidates who referred to the ions as molecules were penalised.
Marks awarded 0

Q11c Describe how you could use chemical tests on an aqueous solution of ammonium sulfate to prove that it contains ammonium ions and sulfate ions. [4]

Student's response

Firstly add sodium hydroxide solution and test the gas given off with red litmus which will turn blue. Test this gas with a rod dipped in concentrated hydrochloric acid and it will give off misty fumes. This shows ammonium is present. For sulphate ion add $BaCl_2$ solution and white precipitate will form. This precipitate is $BaSO_4$ showing sulphate ions are present.

Examiner's comments

The mark was lost for not including the need to warm with sodium hydroxide solution. For many candidates marks were lost for not including the word 'solution' when referring to sodium hydroxide and/or barium chloride.
Marks awarded 3

Q12 Some properties of the metals sodium and aluminium are shown in the table below.

metal	charge on metal ion	electronic structure of the atom	melting point /°C
sodium	1+	$1s^2\ 2s^2\ 2p^6\ 3s^1$	98
aluminium	3+	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$	660

Q12a Describe, without using a diagram, the bonding in sodium metal. [2]

Student's response

Attraction between regular arrangement at positive ions in a sea at delocalised elections ∴ is metallic bonding

Examiner's comments

Full marks were achieved in this part of the question by most Grade A candidates. The description of a metallic structure is well known.
Marks awarded 2

Q12b Explain why aluminium has a higher melting point than sodium. [2]

Student's response

Al has a charge of Al^{3+} ∴ Al donates 3 electrons to delocalised sea of electrons for every atom of Al ∴ higher attraction between increased number of delocalised electrons and positive ions, Na only donates one e^- per atom to sea of delocalised electrons.

Examiner's comments

The standard of the answers provided for this part of the question was overall extremely poor. One mark was awarded for stating that aluminum has more delocalised electrons than sodium. Few candidates achieved the second mark for recognising the greater nuclear charge of the aluminum ion over the sodium ion.
Marks awarded 1

Q12c(i) Write the equation, including state symbols, for the first ionisation energy of sodium. [2]

Student's response

$Na(g) \rightarrow Na^{+}(g) + e^{-}$

Examiner's comments

Correct equation and state symbols provided.
Marks awarded 2

Q12c(ii) The first six ionisation energies, in $kJ\,mol^{-1}$, of sodium are 496, 4563, 6913, 9544, 13352 and 16611. Explain which of these values can be used to identify sodium as belonging to Group I of the Periodic Table. [2]

Student's response

The largest increase between the ionisation energies is between 496 and 4563 ∴ between 1st ionisation energy and 2nd ionisation energy the outermost electron is closer to the nucleus ∴ subjected to less shielding and shorter distance ∴ higher effective nuclear charge ∴ harder to remove – more energy required, outermost electron in Na is in a higher energy level than 2nd outermost electron, easier to remove ∴ group 1

Examiner's comments

Grade A candidates achieved both marks in this part as they answered exactly the question asked. One mark is awarded for stating the two values used and the second mark for recognising that there is a large gap between these values.
Marks awarded 2

Q12c(iii) The outer electron in the sodium atom is located in the 3s orbital. Explain what is meant by the term **orbital**. [2]

Student's response

Volume of space an electron is most likely to be in (spends most of its time in) each orbital can hold up to 2 electrons provided both are of opposite spin. You can get an s, p or d orbital

Examiner's comments

The definition of an orbital is in the specification (1.2.9). One mark was awarded for stating that an orbital is a volume of space (region within an atom) which can hold up to two electrons. The second mark was awarded for recognising that the electrons have opposite spin.
Marks awarded 2

Q12d(i) Explain what is meant by the term **covalent bond**. [2]

Student's response

electrostatic attraction between shared pair of electrons and the nuclei of bonded atoms

Examiner's comments

The definition of a covalent bond appears both in the 'Clarification of Terms' document and in the specification (1.3.3). This definition was often not well known by Grade A students.
Marks awarded 2

Q12d(ii) Write the equation for the reaction of aluminium with chlorine to form aluminium chloride, $AlCl_3$. [1]

Student's response

$2Al + 3Cl_2 \rightarrow 2AlCl_3$

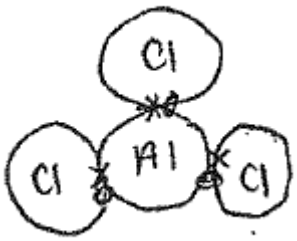
Examiner's comments

The correct balanced equation for the formation of $AlCl_3$ is provided.
Marks awarded 1

Q12d(iii) State the octet rule and explain whether the atoms in aluminium chloride obey the rule. [3]

Student's response

When reacting atoms like to gain, lose, share electrons to achieve a total of 8 electrons in its outer shell. Aluminium does not obey the octet rule only has total share of 6 electrons in its outer shell. however the chloride ions do have a share of 8e- in outer shell.so they do obey the octet rule.

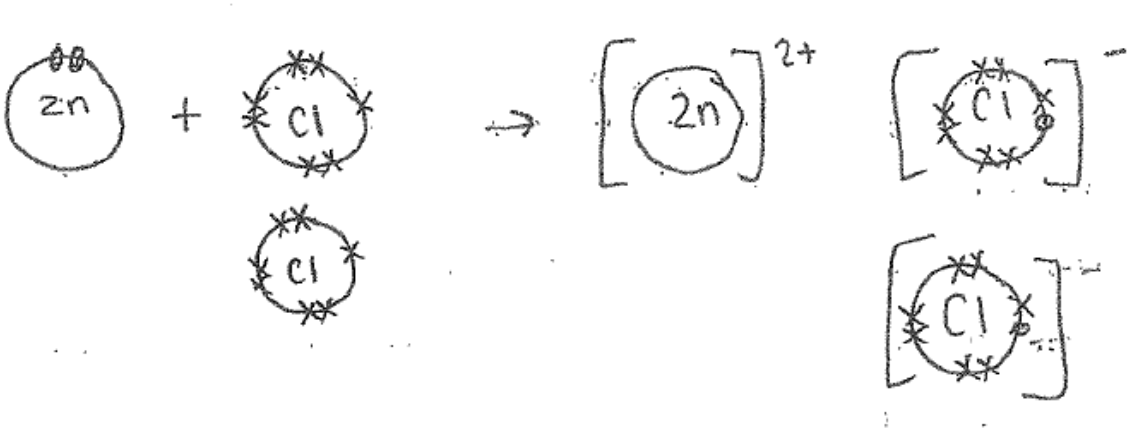


Examiner's comments

The first two marks have been awarded for the standard description of the octet rule. The third mark has not been awarded because the candidate has referred to chloride ions in $AlCl_3$ rather than chlorine atoms. Incorrect chemistry is penalised.
Mark awarded 2

Q13a Zinc reacts with chlorine to form the ionic compound zinc chloride. Draw a dot and cross diagram, using outer electrons only, to show how zinc chloride, $ZnCl_2$, is formed from zinc and chlorine atoms. [2]

Student's response



Examiner's comments

The two marks for this question were for the correct structures of the zinc and chlorine atoms and ions using dot and crosses for the electrons and the correct charges for the ions. The most common error was to show four electrons in the outer shell of the zinc atom. However, error carried forward was applied so that candidates who showed two electrons in the ion attained one mark. Candidates who provided a covalent structure for zinc chloride lost both marks.
Marks awarded 2

Q13b Zinc is an essential trace element. People who have a zinc deficiency can take hydrated zinc sulfate, $ZnSO_4.xH_2O$, as a dietary supplement.

The value of x can be determined by heating hydrated zinc sulfate to constant mass.

A student heated 5.65 g of hydrated zinc sulfate and obtained 3.85 g of anhydrous zinc sulfate.

Q13b(i) Calculate the number of moles of anhydrous zinc sulfate obtained. [1]

Student's response

3.85/161 = 0.024

Q13b(ii) Calculate the mass of water present in the hydrated zinc sulfate. [1]

Student's response

5.65 – 3.85 = 1.8 g

Q13b(iii) Calculate the number of moles of water present in the hydrated zinc sulfate. [1]

Student's response

1.8/18 = 0.1

Q13b(iv) Calculate the value of x in $ZnSO_4.xH_2O$ [1]

Student's response

0.1/0.024 = 4.16 = x = 4

Examiner's comments

This question was well answered by all Grade A candidates. Errors were carried through to the final step and credit was given. Some candidates lost marks for not including a unit for mass in part **(ii).**
Marks awarded 4

Q13c Describe how you would prepare 250.0 cm^3 of a 28.7 g dm^{-3} zinc sulfate solution from the anhydrous solid.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms. [6]

Student's response

Place a weighing boat on weighing scales. Reset scales to 0. Using a spatula transfer (28.7 ÷ 4 = 7.175) 7.175 g of the anhydrous solid onto the weighing boat. Transfer this solid into a beaker 50 cm^3 and fill with deionised water. Ensure you rinse the weighing boat with deionised water into beaker too. Use glass rod to stir and ensure all the solid dissolves. Rinse glass rod with deionised water. Pour beaker and contents into a volumetric Flask (250 cm^3) using a funnel. Add deionised water to beaker + then after funnel and pour rinsing into the volumetric flask. Add deionised water up to just before graduated mark. Use pipette to add drops of deionised water so the menisus lies just on the line. Stopper volumetric flask and shake, to ensure the solution is evenly spread out (same concentration of zinc sulphate throughout.)

Examiner's comments

Overall the quality of responses provided was disappointing. However most Grade A candidates scored a minimum of four of the six available marks. The candidate has been deducted a mark as 'shaking' a filled volumetric flask will not provide a homogenous solution.
Marks awarded 5

Q14 Nitrogen and phosphorus are Group V elements. They form the toxic hydrides ammonia and phosphine.

Q14a Ammonia is formed by the reversible reaction of nitrogen with hydrogen. Write the equation for this reaction. [2]

Student's response

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

Examiner's comments

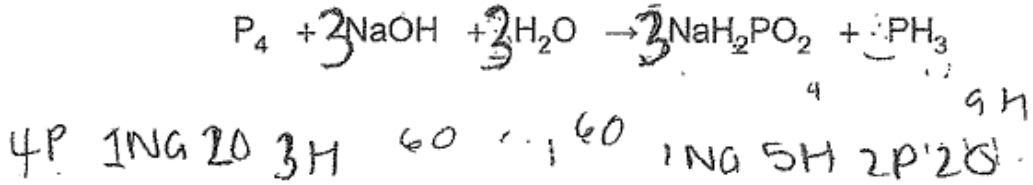
This equation was very well known.
Marks awarded 2

Q14b Phosphine is formed by the reaction of phosphorus with aqueous sodium hydroxide.

Q14b(i) Balance the equation for the formation of phosphine. [1]

$$P_4 + NaOH + H_2O \rightarrow NaH_2PO_2 + PH_3$$

Student's response



Examiner's comments

The balancing of this equation proved extremely challenging for the majority of candidates.
Marks awarded 1

Q14b(ii) Deduce the oxidation number of phosphorus in: [3]

P_4 _____

NaH_2PO_2 _____

PH_3 _____

Student's response

0
+1
-3

Examiner's comments

Full marks was achieved in this part of the question by most Grade A candidates.
Marks awarded 3

Q14b(iii) Explain, using the oxidation numbers of phosphorus, why the reaction is described as disproportionation. [3]

Student's response

This is a disproportionation reaction as the element P is being oxidised & reduced in the same reaction. P is oxidised from O to +1 in NaH_2PO_2 & reduced from 0 to -3 in PH_3.

Examiner's comments

The first scoring mark is awarded for the definition of disproportionation. The remaining two marks are awarded for providing the change in oxidation numbers for Phosphorus that indicate oxidation and reduction in the reaction.
Marks awarded 3

Q14c The boiling point of ammonia is –33 °C while that of phosphine is –88 °C. Explain why the boiling point of ammonia is higher than that of phosphine. [3]

Student's response

NH_3 and phosphine both contain van der waals forces, however ammonia also includes hydrogen bonds between its molecules, these bonds are much stronger than van der waals, which are only present in phospine.

Examiner's comments

The type of intermolecular bonds found between both ammonia and phosphine are known. In addition, the candidate has related the stronger intermolecular bonding between molecules of ammonia to it having a higher boiling point. Generally, this question was not well answered by Grade A candidates.
Marks awarded 3

Q14d Both ammonia and phosphine molecules react with H^+ ions.

$$PH_3 + H^+ \rightarrow PH_4^+$$

Q14d(i) Name the type of bond formed between a phosphine molecule and the H^+ ion. [1]

Student's response

Co-ordinate bond.

Examiner's comments

This was well known with the majority of students gaining the mark.

Marks awarded 1

Q14d(ii) Draw and name the shapes of the molecule PH_3 and the ion PH_4^+.

PH_3

Shape _____

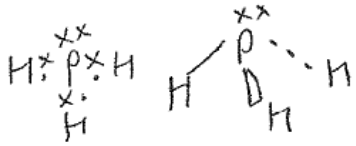
PH_4^+

Shape _____

[4]

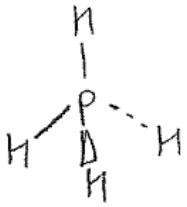
Student's response

PH_3



pyramidal

PH_4^+



tetrahedral

Examiner's comments

The correct shapes of the structures for PH_3 and PH_4^+ are provided.

The name of each structure displayed is correct.

Marks awarded 4

Q14d(iii) Explain why the bond angle in PH_3 is different from the bond angle in PH_4^+ [3]

Student's response

In PH_3 the bond angle is 107° but in PH_4^+ it is 109.5°. This is due to the lone pair of electrons on the phosphine in PH_3. Lone pairs have a greater repulsive power than what bonding pairs have, so the bond angle is reduced. The bonding pairs of e^-s in PH_4^+ repel each other equally

Examiner's comments

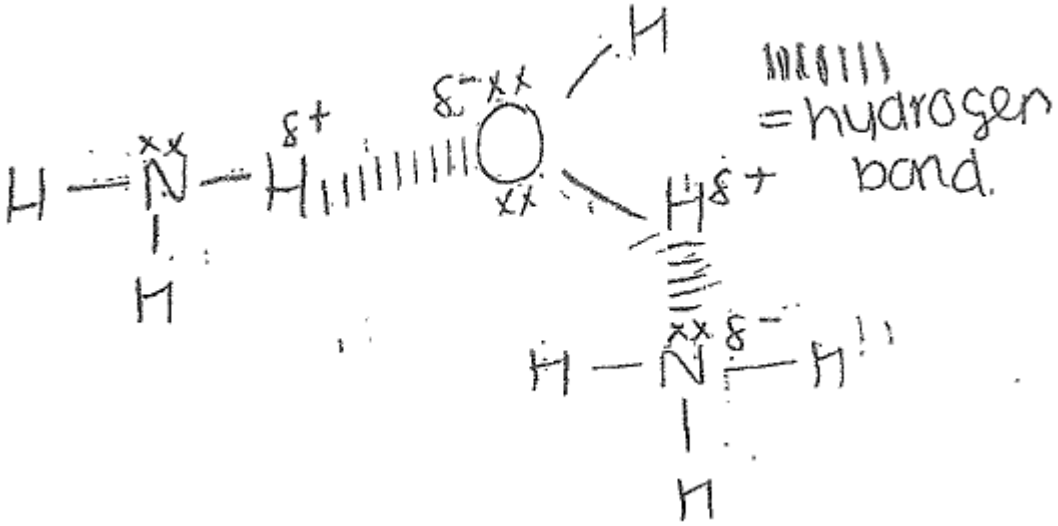
The candidate has stated that PH_3 has a different bond angle than PH_4^+ because of the lone pair of electrons which repel the bonding pairs closer together. While the majority of Grade A candidates scored well in this part of the question, some candidates did lose a mark for stating that the lone pair repelled the hydrogen atoms closer together.

Marks awarded 3

Q14e Ammonia is very soluble in water. Draw diagrams to show the two ways in which a molecule of ammonia can be attracted to a molecule of water. Include all partial charges and lone pairs in your diagram. [4]

Student's response

Due to the very electronegative oxygen atom with a lone pair of electrons in water it can form a hydrogen bond between that oxygen (δ^-) and the hydrogen in NH_3^+ (δ^+)



A hydrogen bond can also form between the electronegative nitrogen atom with one lone pair of electrons (which has a delta negative charge) and the H atoms on H_2O molecule which has a delta positive charge.

Examiner's comments

The quality of responses provided in this question was overall extremely poor. The main reason for this is that candidates did not answer fully the question asked. Each error resulted in one mark being deducted up to a maximum of four marks. The candidate has not included all partial charges on the hydrogen atoms. The second mark is lost as the candidate does not show the hydrogen bond from a lone pair on the oxygen atom of the water molecule.

Marks awarded 2

Q15 Ammonia is used to make nitric acid by the Ostwald Process outlined below.

Reaction 1: $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

Reaction 2: $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

Reaction 3: $3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$

Q15a(i) Calculate the number of moles of oxygen needed to react with 6.8 kg of ammonia. [3]

Student's response

moles = $\frac{6.8}{17}$
= 0.4

ratio = 4 : 5 moles = 0.5 moles

Examiner's comments

A common error made by many candidates was omitting to convert the mass of ammonia from Kilograms to grams. As this script shows, error carried forward was applied, allowing the candidate to score two of three available marks.
Marks awarded 2

Q15a(ii) Calculate the number of moles of nitrogen(IV) oxide which can be obtained from 6.8 kg of ammonia. [2]

Student's response

0.4 moles 4 : 4 0.4 moles

Examiner's comments

The candidate has used the moles of ammonia calculated in **(a)(i)** and has applied the correct 1:1 ratio
Marks awarded 2

Q15a(iii) Calculate the concentration of nitric acid, in g dm^{-3}, produced on reacting the nitrogen(IV) oxide obtained in part **(ii)** with 50 dm^3 of water. [3]

Student's response

0.4 3 : 2 = 0.267 moles HNO_3

$$c = \frac{m \times 1000}{v} = \frac{0.267}{50} = 0.0053\ gdm^{-3}$$

Examiner's comments

The correct ratio has been applied and the number of moles of nitric acid calculated. The correct conversion of moles to concentration has been provided. However, the candidate has failed to convert correctly to g dm^{-3} by multiplying by the RMM of HNO_3.
Marks awarded 2

Q15b Ammonia reacts with nitric acid according to the equation below.

$$NH_3 + HNO_3 \rightarrow NH_4NO_3$$

The following results were obtained by diluting 25.0 cm^3 of a concentrated ammonia solution to 250.0 cm^3 in a volumetric flask and then titrating 25.0 cm^3 portions of the diluted ammonia solution using 0.100 mol dm^{-3} nitric acid.

titration	initial burette reading /cm^3	final burette reading /cm^3	titre /cm^3
rough	0.00	22.00	22.00
first accurate	0.10	21.40	21.30
second accurate	0.20	21.60	21.40

Q15b(i) Name a suitable indicator for the titration and state the colour change at the end point. [3]

Student's response

Methyl orange, yellow to red

Examiner's comments

Indicator and correct colour change were given.
Marks awarded 3

Q15b(ii) Calculate the mean titre. [1]

Student's response

$$\frac{(21.3 + 21.4)}{2} = 21.35\ cm^3$$

Examiner's comments

The correct value with units are provided.
Marks awarded 1

Q15b(iii) A burette has an uncertainty of ±0.05 cm^3. Calculate the uncertainty when two burette readings are used to calculate a titre value. [1]

Student's response

$\frac{0.1}{21.35} \times 100 = 0.468\ \%$

Examiner's comments

The value for uncertainty has been expressed as a percentage. The mark scheme was adjusted to accommodate this answer as an acceptable alternative to 0.1 cm^3.
Marks awarded 1

Q15b(iv) Calculate the concentration of the concentrated ammonia solution in mol dm^{-3}. [5]

Student's response

$moles = \frac{vc}{1000} = \frac{21.35 \times 0.1}{1000} = 0.02135$ moles nitric acid

1:1 mole ratio = 0.02135 moles of dil ammonia

moles of conc ammonia = 0.02135 x 10 = 0.2135 moles

$c = \frac{m \times 1000}{v} = \frac{0.2135 \times 1000}{25} = 8.54\ mol\ dm^{-3}$

Examiner's comments

Overall the standard of answers provided by Grade A candidates was poor. Candidates had difficulty with this unstructured calculation and few gained all five available marks. This candidate has correctly used the mean titre from **(b)(ii)** to calculate the number of moles of nitric acid. However, an incorrect value has been written down from the calculator and the candidate has been deducted one mark. The error has been carried forward. Using the 1:1 ratio, the number of moles of ammonia in 25 cm^3 of solution has been calculated. The candidate has correctly calculated the concentration of the undiluted ammonia solution and the correct units have been given.
Marks awarded 4

GCE: AS CHEMISTRY

SCH22 Further Physical and Inorganic Chemistry and an Introduction to Organic Chemistry

Grade: A Exemplar

Section B

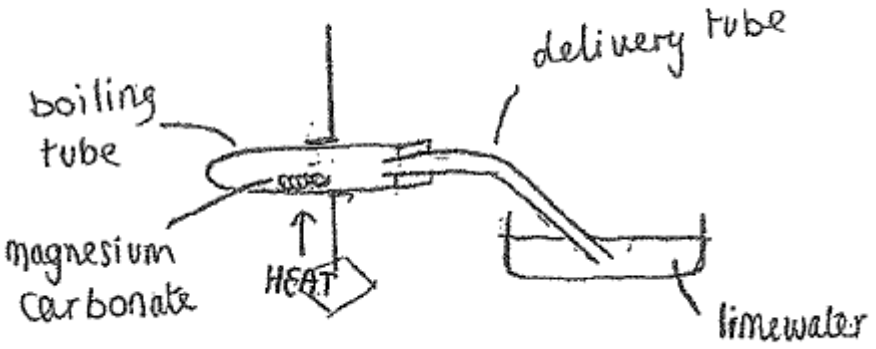
Answer all seven questions in the spaces provided.

Q11 A student carried out a series of activities to investigate the chemistry of Group II elements and compounds.

Q11a The student heated magnesium carbonate in a boiling tube and bubbled the gas produced through a suitable reagent to identify the gas.

Q11a(i) Draw a diagram of the assembled apparatus and name the reagent used. [2]

Student's response



Examiner's comments

This answer gained two marks, the diagram had labels attached but this was not necessary. The reagent was named as required. Even though it was placed in what appeared to be a trough this did not matter, all the essentials were correct.

Q11a(ii) Write an equation for the thermal decomposition of magnesium carbonate. [1]

Student's response

$MgCO_3 \rightarrow MgO + CO_2$

Examiner's comments

The equation was correctly written i.e. the formulae of reactants and products were correct. There was no balancing to do and the one mark on offer was obtained. Equations are normally right or wrong.

Q11a(iii) Explain why magnesium carbonate decomposes much more readily than calcium carbonate when heated. [2]

Student's response

Magnesium has a greater charge density than Barium as Magnesium ions is smaller than Barium ions but both have the same charge. The Magnesium ion is able to polarise or destabilise the carbonate ion more efficiently than the Barium ion therefore less energy is required.

Examiner's comments

This question should have been familiar to most candidates as it has appeared on CCEA GCE chemistry papers for many years. In this case it carried two marks rather than three marks. Despite this apparent familiarity, grade A candidates obtained 0, 1 and 2 marks. This candidate mentioned that "magnesium has a greater charge density than barium" which could have been penalised but then immediately said that "as magnesium ions is (sic)……". Usually this would have been penalised as atoms were initially implied. It was also stated that the magnesium ion was smaller than the barium ion but the mark had been obtained by then. Previous mark schemes had either been well learnt or studied because both of the statements in the mark scheme were mentioned and both marks were obtained.

Q11b The student added a solution of sodium hydroxide to a solution of magnesium nitrate. A white precipitate was formed.

Q11b(i) Name the precipitate. [1]

Student's response

$Mg(OH)_2$

Examiner's comments

Although the question asks candidates to name the precipitate it is usual in all CCEA GCE chemistry examinations to accept formulae in place of names. If both name and formula are given then emphasis is placed on the name because the name has been asked for in the question. Hence, if the name was incorrect and the formula was correct the mark would not be awarded. This candidate gave a correct formula and the mark was awarded.

Q11b(ii) Write an ionic equation, without state symbols, for the formation of the precipitate. [1]

Student's response

$Mg^{2+} + 2OH^- \rightarrow Mg(OH)_2$

Examiner's comments

There is one mark for this equation which was gained. If there had only been one hydroxide ion written it would have been lost. If state symbols had been included they would have had to be correct otherwise the mark would have been lost.

Q11c The student added a solution of potassium sulfate to a solution of barium nitrate. A white precipitate was formed.

Q11c(i) Name the precipitate. [1]

Student's response

Barium Sulfate

Examiner's comments

The only answer was barium sulfate and was awarded the mark. Sulfate could have been written as sulphate without any penalty. It would only be considered if quality of written communication was being assessed and even then it might not be penalised depending on other errors being made in the answer.

Q11c(ii) Write an ionic equation, including state symbols, for the formation of the precipitate. [2]

Student's response

$Ba^{2+}(_{aq}) + SO_4^{2-}(_{aq}) \rightarrow BaSO_4(_s)$

Examiner's comments

The symbol (s) is below the formula but this is not penalised. Many textbooks now have their state symbols much lower than the formulae.

Q11d The student then burnt magnesium using a Bunsen burner.

Q11d(i) Give **two** observations. [2]

Student's response

Bright white spark/light
White powder solid remains

Examiner's comments

The candidate has written "a bright white spark/light". The mark scheme says (bright) white light. It was considered that "spark" was not wrong and the mark was given. The mark scheme says white solid but a white powder is correct. In the laboratory magnesium is often used as a powder and magnesium ribbon burns to form a powder. The question does not mention the state of the magnesium. Statements in the mark scheme are very short and may be expanded in candidates' answers. The candidate gained both of the marks for the question.

Q11d(ii) Write an equation for the reaction. [1]

Student's response

$2Mg + O_2 \rightarrow 2MgO$

Examiner's comments

There is one mark for the question which means everything has to be correct which it is and the one mark is awarded.

Q12 There are five structural isomers with molecular formula C_6H_{14}.

Q12a What is meant by the term **structural isomers?** [2]

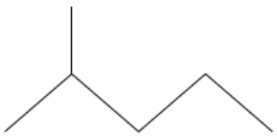
Student's response

Substances with the same molecular formula but different structural formula.

Examiner's comments

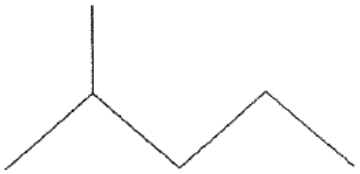
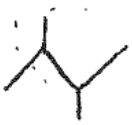
There are several ways of answering the question but the mark scheme answer was the one used by most candidates and by this candidate. Note that the candidate has not said anything else which may have jeopardised the answer. The two marks were awarded.

Q12b Four of the structural isomers are described as having branched structures.
Complete the table below.

name of branched isomer	skeletal formula
2-methylpentane	

[3]

Student's response

name of branched isomer	skeletal formula
2-methylpentane	
3- methyl pentane	
2,3 - dimethyl butane	
2,2 - dimethyl butane	

Examiner's comments

To get the three marks in this question both the structure of the hydrocarbon and the name of the hydrocarbon had to be correct. Most grade A candidates obtained full marks for this question as did this candidate. However, quite a few grade A candidates lost a mark. With six points to get correct any inaccuracy lost a mark. There are two possible ways to draw the structure of 2,2-dimethylbutane. This candidate chose the least popular way but it was just as correct.

Q12c Explain why the unbranched isomer, hexane, has a higher boiling point than any of the branched isomers. [2]

Student's response

Hexane isn't branched which allows it to be closer or come in contact to other Hexane molecules. This means greater Van der Waal's forces between the molecules increasing the energy required. Branched molecules can't interlink so weaker Van der Waals

Examiner's comments

The question says that hexane is unbranched. This gives a clue to the answer required but it also means that statements on branching are not accepted for marks and are not featured in the mark scheme. This candidate mentions they come closer but the key word is "contact" which the candidate mentions. "Greater van der Waal's (sic) forces secures the second mark. Almost the exact words are used from the mark scheme.

Q12d(i) Write an equation for the complete combustion of hexane. [2]

Student's response

$C_6H_{14} + 9.5O_2 \rightarrow 6CO_2 + 7H_2O$

Examiner's comments

Note that the candidate uses $9.5O_2$ rather than $19O_2$ but the answer is still correct because the equation is correctly balanced. However, if the equation had been doubled this would have been incorrect. Despite being balanced the equation would have been contrary to the normal conventions of chemistry. In this case there are two marks, one for the correct reactants and products and one for the correct balancing. Both are correct and both marks were obtained.

Q12d(ii) Write an equation for the incomplete combustion of hexane. [2]

Student's response

$C_6H_{14} + 6.5O_2 \rightarrow 6CO + 7H_2O$

Examiner's comments

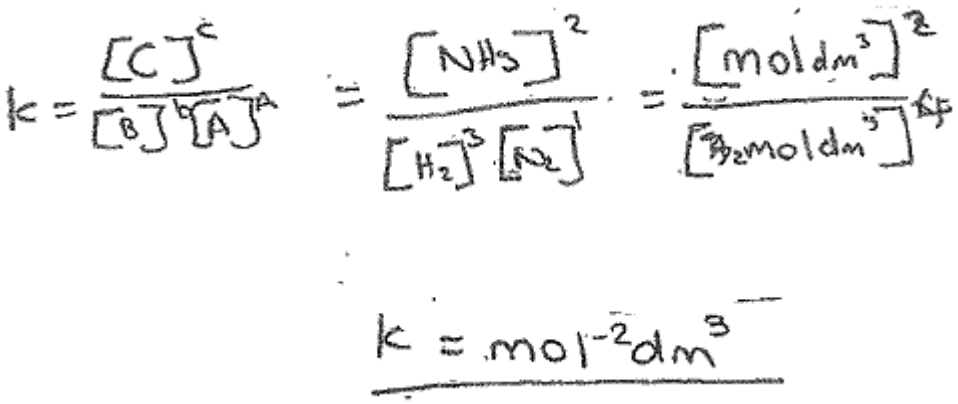
Again, the candidate has used half the number of molecules of oxygen mentioned in the mark scheme but again it is correctly balanced. Full marks are obtained. Grade A candidates tend to do very well on writing balanced chemical equations.

Q13 Ammonia is produced by a reversible exothermic reaction between nitrogen and hydrogen:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Q13a(i) Write an expression for the equilibrium constant, K_c, and deduce its units. [2]

Student's response



Examiner's comments

The idea of equilibrium, at AS level, is a new feature of the new specification. Although grade A candidates managed to obtain a mark in this question it was very rare to obtain the two marks available. As with many candidates this candidate managed to obtain the correct equilibrium expression but then an error is made in obtaining the correct units. $Mol^{-2}\ dm^{-3}$ is obtained rather than $mol^{-2}\ dm^6$. Consequently one mark was obtained. A wide variety of incorrect units were obtained despite a correct equilibrium expression being obtained.

Q13a(ii) What does a small value of K_c indicate about this equilibrium? [1]

Student's response

It is shifted to the left in favour of the reaction forming the reactants (N_2 + $3H_2$), low yield of ammonia

Examiner's comments

This candidate obtained the mark in the first few words i.e. "it is shifted to the left". The rest of the answer is correct. Care has to be taken because if the candidate had said the yield was increased then two contradictory statements would have been made and the mark would have been lost.

Q13b The Haber process, for the production of ammonia, uses a temperature between 400 °C and 500 °C, a pressure of approximately 200 atm and an iron catalyst.

Q13b(i) Explain why the yield improves at a temperature of 300 °C at constant pressure. [2]

Student's response

The equilibrium shifts to the right in favour of the exothermic reaction which absorbs the additional heat. Therefore improving the yield. Constant pressure ensures the equillibrium doesn't shift to reduce or raise pressure.

Examiner's comments

This candidate gives the correct answer by mentioning that the reaction shifts to the right and mentions the exothermic reaction and gains two marks. Interestingly the candidate goes on to mention the constant pressure. Although the candidate correctly mentions that constant pressure ensures the equilibrium does not shift it would not have mattered if the statement had been wrong because the question asked is all about temperature and pressure is not mentioned.

Q13b(ii) Explain why the production of ammonia is **not** carried out at 300°C. [1]

Student's response

It would be outside of the compromise temperature range, therefore meaning that an increase in yield would effect the rate of reaction. Even though more yield is collected, the rate may be too slow. Decrease Rate of Reaction.

Examiner's comments

It was always a rule of the past to let the number of lines determine the marks available. In this case the candidate took four lines to answer when it could have been done in one line. The correct answer was given at the end of the response and gained the mark.

Q13b(iii) Explain why the yield improves when the pressure is 1000 atm at a constant temperature. [2]

Student's response

There are fewer gas moles on the right hand side, 2, compared to the left hand side, 4. The equilibrium shifts right which is the side with less gas moles so therefore a higher yield.

Examiner's comments

All of the statements made are correct and the candidate obtains the two marks. The answer could have been shorter. Stating that the yield is higher is restating the question which says that the yield improves.

Q13b(iv) Explain why the production of ammonia is **not** carried out at 1000 atm. [1]

Student's response

High pressure is expensive to maintain and thick pipes are needed

Examiner's comments

The answer that the process would be more expensive was not sufficient. Further stating that it would be too expensive to obtain the 1000 atm pressure was not a sufficient explanation either. This candidate stated that thicker pipes were needed and obtained the mark. The mark scheme says that more steel is accepted and so it would be if thicker pipes were needed.

Q14 It is often possible to distinguish between organic molecules by using infrared spectroscopy or simple test tube reactions.

Q14a Explain why, without access to a database of infrared spectra, it is difficult to distinguish between butan-2-ol and 2-methylpropan-2-ol using infrared spectroscopy. [2]

Student's response

They would both have base peaks that correspond with an –OH group and C-C bonds and C-H bonds. Without a database it would be difficult as they are so similar.

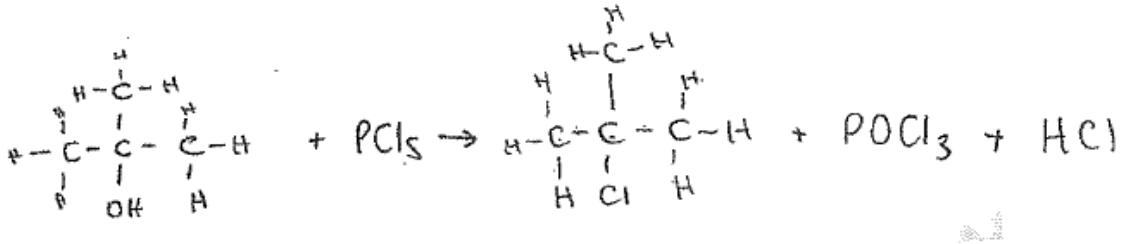
Examiner's comments

It was rare for any grade A candidate to obtain two marks for this question. This candidate obtained one mark which was the norm. There appears to be a weakness with IR throughout all of the past papers for CCEA GCE chemistry. It is not said that the same bonds are present but the bonds are listed and they are correct. This candidate and many others are inclined to mention databases but the mark scheme says that the peaks are in the same place. The databook, if consulted, would have had to say that the peaks were in the same place.

Q14b Butan-2-ol and 2-methylpropan-2-ol give the same observations when reacted with phosphorus pentachloride.

Q14b(i) Write an equation for the reaction of 2-methylpropan-2-ol with phosphorus pentachloride. [2]

Student's response



Examiner's comments

The space provided for the answer was greater than normal because it was expected that candidates would take the opportunity to write the structure of the alcohol and hence to write it correctly. If the molecular formula of the alcohol was written it was inevitable, even with strong grade A candidates, that they would not give the structure of the alcohol stated in the question. This candidate took the hint and drew the full structure of the alcohol and hence gained the available two marks.

Q14b(ii) Name the organic product. [1]

Student's response

2–chloro–2–methylpropane

Examiner's comments

The answer is correct and the mark was obtained despite there being a slight gap between the methyl and the propane. This would have been penalised in the past but the effort to determine whether there is a gap is very subjective.

Q14c Describe how you could use simple test tube reactions to distinguish between butan-2-ol and 2-methylpropan-2-ol. Your answer should include reagents, conditions, observations and an explanation of the chemistry involved.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms. [6]

Student's response

Take a sample of both alcohols and place equal amounts into separate test tubes. Add 5cm^3 of acidified potassium dichromate to each test tube. Place both test tubes in a water bath at around 90°C. In the butan-2-ol a colour change will be observed from orage to green. There will be no colour change of the acidified potassium dichromate in the 2-methylpropan-2-ol. This is because, butan-2-ol is a secondary alcohol meaning it has 2 carbons attached to the carbon with the OH group whereas 2-methylpropan-2-ol is a tertiary alcohol. Tertiary Alcohols are resistant to mild oxidation so therefore don't change the colour from orange to green.

Examiner's comments

Questions using indicative content are a new feature of CCEA GCE chemistry. Most candidates at grade A performed well. This new type of question tended to discriminate more than the old quality of written communication question possibly because of the greater number of marks available. The former QwC questions tended to have the two marks for QwC awarded virtually automatically. Candidates at grade A did well as did this candidate who obtained six marks. It was interesting to see that all of the number of lines presented were used by this candidate and two more.

Q15 Enthalpies of neutralisation can be determined using experimental methods.

Q15a What is meant by the term **enthalpy of neutralisation**? [2]

Student's response

The enthalpy change when 1 mole of water is produced in a neutralisation reaction from the reactants under standard conditions.

Examiner's comments

Candidates at grade A normally learn definitions very well but this definition defeated many of them but only slightly i.e. one mark was obtained rather than two. This candidate gave what was stated in the mark scheme and obtained the two marks. The candidate also stated that it was under standard conditions as many other candidates did. This was additional information and not penalised because it would be at one atmosphere and the temperature might be room temperature or not.

Q15b An enthalpy of neutralisation was determined using the following method.

Add 50 cm^3 of 2.0 mol dm^{-3} hydrochloric acid to a polystyrene cup. Add 50 cm^3 of 2.0 mol dm^{-3} sodium hydroxide solution to a different polystyrene cup. Place thermometers in each solution and leave until both temperatures are equal. Record the temperature. Transfer the alkali into the acid and stir. Record the maximum temperature reached.

The following results were obtained:

initial temperature □ 20.0 □C

maximum temperature reached □ 33.3 □C

Q15b(i) Which piece of apparatus should be used to add 50 cm^3 of 2.0 mol dm^{-3} hydrochloric acid to the polystyrene cup? [1]

Student's response

pipette

Examiner's comments

There was a wide range of apparatus which could have been supplied as an answer. Inevitably most candidates obtained the correct answer. This candidate supplied the answer 'pipette' and obtained the mark.

Q15b(ii) What is the advantage of using a polystyrene cup? [1]

Student's response

Used to insulate the heat/no heat lost.

Examiner's comments

Again, this was a relatively easy question and any mention of insulation obtained the mark which this candidate did by saying "insulate the heat".

Q15b(iii) Write an equation for the neutralisation reaction. [1]

Student's response

$HCl + NaOH \rightarrow NaCl + H_2O$

Examiner's comments

This was an extremely straightforward equation which was well known by all candidates at all levels. All grade A candidates obtained this mark as did this candidate.

Q15b(iv) Assuming that the mass of the solution (in grams) is equal to its volume (in cm^3) and that the heat capacity of the solution is 4.2 J g^{-1} K^{-1}, use the equation q = mcΔT to calculate the heat energy released (in Joules). [2]

Student's response

ΔH = -100g x 4.2 J g^{-1} K^{-1} × 13.3 K
= -5586 J
5586 J released

Examiner's comments

Candidates were quite capable of working out the calculation but then had difficulty with the "sign" of the heat energy released. This answer is interesting because the candidate has shown a negative sign but then, in the final answer, given the number of joules without a negative sign and obtained the two marks available.

Q15b(v) Calculate the number of moles of water produced. [1]

Student's response

0.1 mol
1Ξ1 HCl n = [JxV = 2 × 0.05 = 0.1 mol

Examiner's comments

The answer given by all grade A candidates was 0.1 moles/mol of water. This candidate gave the answer 0.1 mol and obtained the mark. However, although the vast majority stated mol/mole/moles there was no need to do so because the question had asked for the number of moles of water produced. Hence mol/mole/moles could have been omitted.

Q15b(vi) Calculate the enthalpy of neutralisation in kJ mol^{-1}. [3]

Student's response

$\frac{-5586}{1000} = \frac{-5.586\ kJ}{0.1} = -55.86\ kJmol^{-1}$

Examiner's comments

The answer was required in kJ and most grade A candidates realised this. Also the answer had to have a negative sign because the reaction was exothermic. This candidate satisfied all of the requirements and obtained the three marks.

Q15b(vii) Suggest why the value calculated may be different from the data book value. [1]

Student's response

heat could have been lost to the surroundings or the mass of the solution isn't equal to its volume

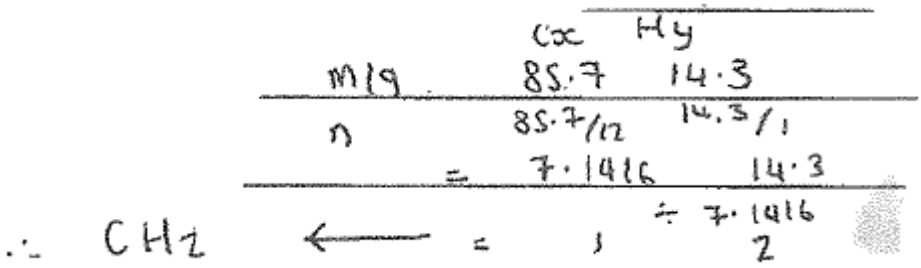
Examiner's comments

This candidate stated that heat could be lost to the surroundings which was the correct answer and was in the mark scheme and gained the mark. The additional "assumption" was mentioned in the introduction i.e. that the mass of the solution is equal to its volume so there was no problem in mentioning it again but it could never have gained a mark because it was mentioned at the start of the question.

Q16 A hydrocarbon contains 85.7% carbon by mass.

Q16a Calculate the empirical formula of this hydrocarbon using its percentage composition. [2]

Student's response



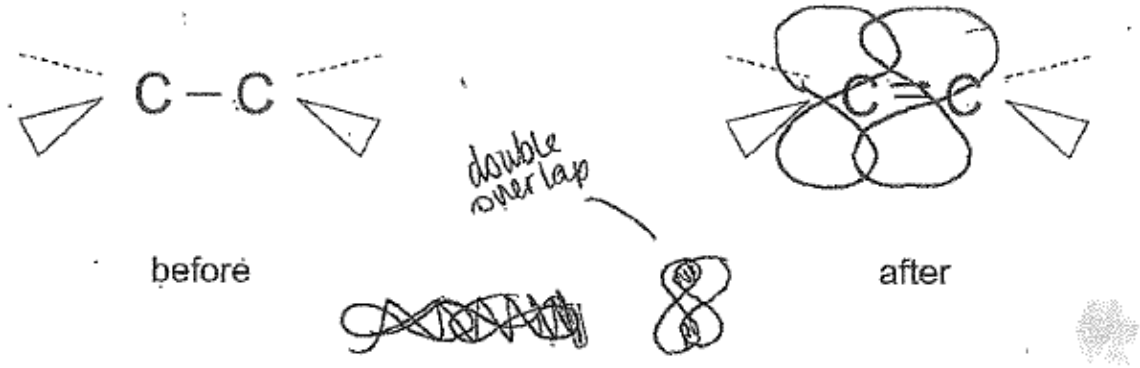
Examiner's comments

This was a very straightforward question for all candidates and grade A candidates inevitably obtained the two marks as did this candidate. The candidate calculated the number of moles of carbon to four decimal places which was good practice but it would not have mattered in this case as it did not affect the ratio of atoms obtained.

Q16b The C=C bond and the four atoms which are attached to the carbon atoms all lie in the same plane.

Q16b(i) Complete the diagram below to show the formation of the pi bond from two p-orbitals. [1]

Student's response



Examiner's comments

There were very few correct answers for this question. The answer presented by this candidate was on the way to being correct. The right-hand side, "the after side", was correct but nothing was written on "the before side". Both sides needed to be correct so the mark was lost.

Q16b(ii) Explain why the presence of the pi bond makes an alkene more reactive than an alkane. [2]

Student's response

A pi bond is an electron rich area or has a high electron density. This makes it more likely to be attacked by an electrophile.

Examiner's comments

In the mark scheme there were three statements and for two marks the candidate had to obtain two correct statements. This candidate stated that the pi bond was electron rich and that it had a high electron density. Both of these statements were on the same line in the mark scheme and could only obtain one mark. The second mark was obtained by stating that it could be attacked by an electrophile.

Q16c Detailed analysis proved that the hydrocarbon is 2-methylbut-1-ene, $CH_2=C(CH_3)CH_2CH_3$, which reacts with hydrogen bromide to form two organic products.

Q16c(i) Show the polarity of the hydrogen bromide molecule. [1]

H—Br

Student's response

$\delta+$ $\delta-$
H–Br

Examiner's comments

The polarity of the hydrogen bromide molecule was known by most candidates and naturally very well known by grade A candidates. There was no problem with drawing the correct symbols as this candidate did.

Q16c(ii) Name the mechanism for the reaction of 2-methylbut-1-ene with hydrogen bromide. [2]

Student's response

Electrophilic Addition

Examiner's comments

The mechanism for the reaction of 2-methylbut-1-ene with hydrogen bromide was electrophilic addition. There were two marks available, one for each word and most candidates obtained the two marks especially grade A candidates as did this candidate.

Q16c(iii) Name the major organic product. [1]

Student's response

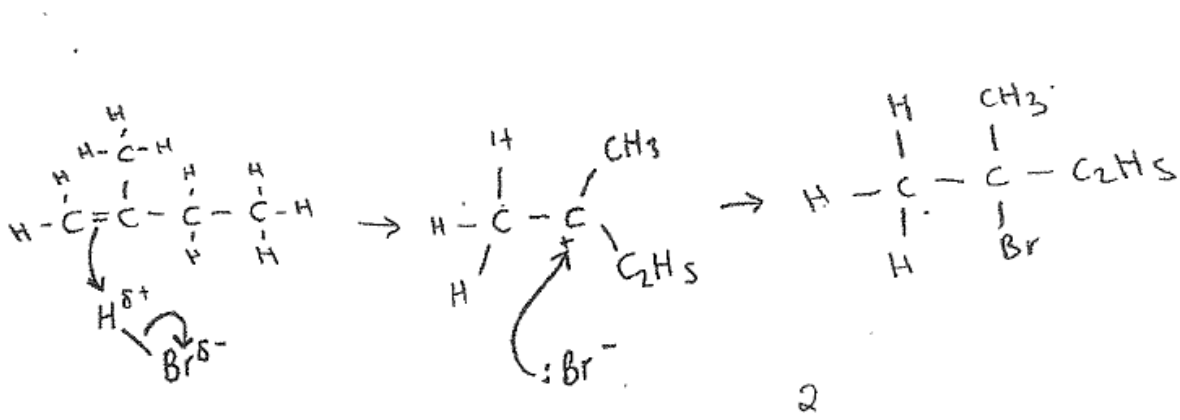
2–bromo–2–methyl butane

Examiner's comments

Names of organic compounds can be complicated if there are numerous dashes and commas. Although the correct name should have the correct spaces written, this candidate has a definite gap between the methyl and the butane which would have been penalised in the past but it is now accepted. The candidate gained the mark. It would have been unfair to penalise a candidate when so much that is written is correct, as in this case.

Q16c(iv) Using curly arrows to show the movement of electron pairs, draw the mechanism for the reaction of 2-methylbut-1-ene with hydrogen bromide to form the major organic product. [4]

Student's response



Examiner's comments

This year was the first year of using curly arrows in the CCEA specification. Some allowance was made with candidates' answers as this was the first year. Although this candidate obtained the maximum number of marks available i.e. four marks, one of the curly arrows is not correct. The curly arrow from the double bond of the alkene points directly to the hydrogen atom. It should point to the space exactly in between the double bond and the hydrogen atom. The other curly arrow is perfectly correct. It goes from the lone pair to the positive charge.

Q16c(v) Explain why the mechanism given in part **(iv)** produces the major organic product. [2]

Student's response

The major product created a secondary carbon cation which is more stable than the minor product which would create a primary carbocation which is less stable. Bromine attacks mostly to the more stable secondary carbocation

Examiner's comments

The stability of carbocations is a new feature of this specification. This question carried two marks and it was very rare indeed, even for grade A candidates, to obtain both marks. This candidate's answer obtained one mark for mentioning that the minor product "would create a primary carbocation". The major product did not "create a secondary carbon cation", it was tertiary. A sizeable number of grade A candidates were quoting Markownikoffs rule in words i.e. the hydrogen will always attach itself to the carbon with the higher number of hydrogens. This statement is not asked for, the question refers to a mechanism.

Q17 When 1-bromopropane is heated with aqueous potassium hydroxide, the hydroxide ions behave as nucleophiles.

Q17a What is meant by the term **nucleophile**? [2]

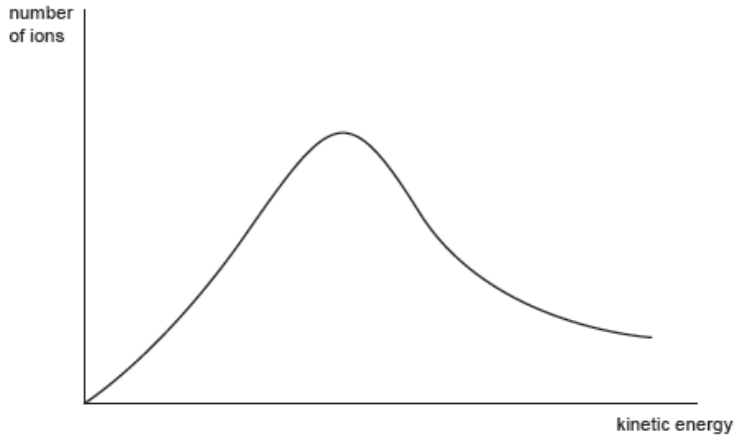
Student's response

An ion or molecule with a lone pair on electrons, which attacks area of low electron density

Examiner's comments

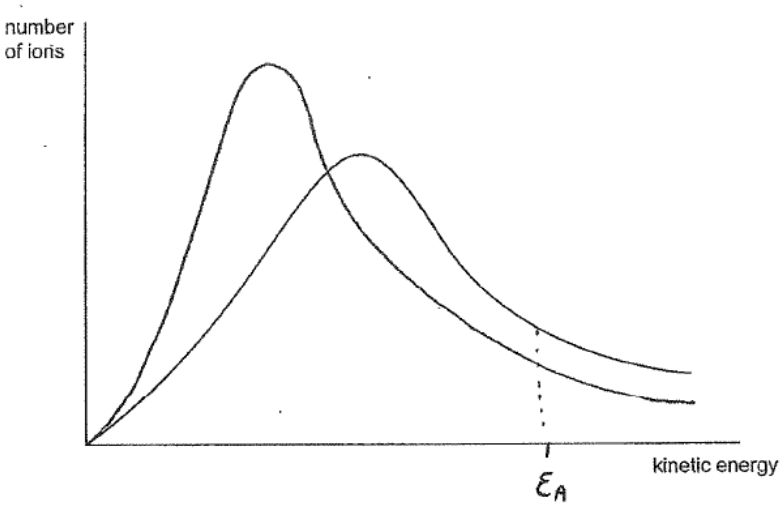
Most candidates had exactly the same answer because the answer had been perfectly learned from the list of definitions supplied by CCEA. This candidate obtained the two marks because "an ion or molecule" was mentioned. If either ion or molecule was missing, a mark would have been lost.

Q17b Most collisions between hydroxide ions and 1-bromopropane molecules do not result in a reaction. The following diagram shows the kinetic energy distribution of hydroxide ions in the reaction mixture:



Q17b(i) On the x-axis above, show a possible position for the activation energy. [1]

Student's response



Examiner's comments

All candidates had little difficulty with marking a possible position for the activation energy. This candidate obtained the one mark. There was no need to draw a dotted line or a solid line upwards. Just the position on the x-axis was needed as asked for in the question.

Q17b(ii) On the same axes, show the kinetic energy distribution of hydroxide ions at a lower temperature. [2]

Student's response

*narrower & higher peak – See Maxwell Boltzmann distribution curve for answer in part **(b)(i).***

Examiner's comments

The kinetic energy distribution provided two marks for most grade A candidates as shown by this candidate. Sometimes there was some doubt if the new curve did not pass exactly through the origin but there is no uncertainty in this answer. The two curves appear to be parallel at the end but there is no need for this in order to gain credit.

Q17b(iii) Use the two distribution curves to explain how the rate of reaction is affected by lowering the temperature. [2]

Student's response

The particles have less kinetic energy meaning there are less successful collisions due to less particles have the Activation Energy. This means a decrease in Rate of Reaction.

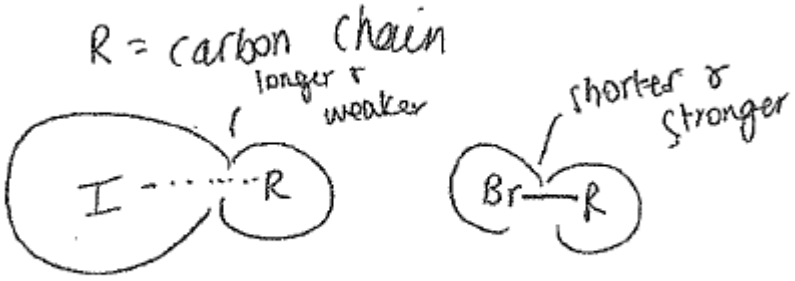
Examiner's comments

Most grade A candidates obtained the two marks as did this candidate. One mark was for the rate of reaction decreasing which candidates usually obtained. The other mark was more problematic because the curves dealt with a change in activation energy. Simply mentioning kinetic energy and successful collisions was not sufficient. Although the question said use the distribution curves, they did not need to be mentioned. This candidate did not mention them and gained full marks.

Q17c Explain how the rate of the reaction between 1-iodopropane with aqueous potassium hydroxide compares with that of 1-bromopropane. [2]

Student's response

1-iodopropane is a faster rate of reaction as it has a longer, weaker halogen – R bond and therefore is substituted by hydroxide ions (OH^-) faster than 1-bromopropane



Examiner's comments

This candidate obtained the mark for the reaction being faster, which was the easier mark. They also gained the second mark for the weaker halogen-carbon bond. Not all candidates at grade A gained the second mark because they referred to lower bond enthalpies in the 1-iodopropane without mentioning which one.

GCE: AS CHEMISTRY

SCH31 Practical Chemistry

Grade: A Exemplar

Q1 You are provided with four solutions labelled **A**, **B**, **C** and **D**.

Q1a Describe the appearance of the solutions. [1]

Student's response

Colourless liquids

Examiner's comments

Marks awarded 1

This was a straightforward observation and the mark was typically obtained as shown.

Q1b Give observations obtained when the procedures listed below are performed.

Q1b(i) Mix 2 cm^3 of **A** with 2 cm^3 of **B** in a test tube. [1]

Student's response

Fizzing - gas released

Q1b(ii) Mix 2 cm^3 of **A** with 2 cm^3 of **C** in a test tube. [2]

Student's response

Cream precipitate formed

Q1b(iii) Mix 2 cm^3 of **A** with 2 cm^3 of **D** in a test tube. [1]

Student's response

Colourless solution forms

Q1b(iv) Mix 2 cm^3 of **B** with 2 cm^3 of **C** in a test tube. [2]

Student's response

White precipitate forms

Q1b(v) Mix 2 cm^3 of **B** with 2 cm^3 of **D** in a test tube. [1]

Student's response

Colourless solution forms

Q1b(vi) Mix 2 cm^3 of **C** with 2 cm^3 of **D** in a test tube. [2]

Student's response

Yellow precipitate forms

Examiner's comments

Marks awarded 9

This question was a series of observation exercises and an A grade candidate typically would achieve full marks. The example shown is a typical A grade answer that expresses the observations in very concise and succinct language, giving the simple observations required without complicating the answer with unnecessary statements.

Q2a You are required to react hydrochloric acid of unknown concentration with standard 2.0 mol dm^{-3} sodium hydroxide solution. [4]

You are provided with:

hydrochloric acid of unknown concentration
2.0 mol dm^{-3} sodium hydroxide solution
a thermometer

- Rinse out a burette with the hydrochloric acid.
- Fill the burette with the hydrochloric acid.
- Rinse out a pipette with the sodium hydroxide solution.
- Using the pipette and a pipette filler, place 25.0 cm^3 of the sodium hydroxide solution in a polystyrene cup in a beaker.
- Measure and record the temperature of the sodium hydroxide solution.
- Add 5.0 cm^3 of hydrochloric acid from the burette to the sodium hydroxide solution, stir and record the temperature in a suitable table.
- Continue adding 5.0 cm^3 portions and recording the temperature, until 40.0 cm^3 of hydrochloric acid solution has been added.
- Repeat the complete experiment to obtain a mean temperature.
- Present your results in a suitable table in the space below.

Student's response

Volume of acid/cm³	*Temperature/ °C of solution*		
	Titration 1	*Titration 2*	*Mean Temp °C*
0	*20*	*20*	*20*
5	*23*	*23*	*23*
10	*27*	*27*	*27*
15	*30*	*30*	*30*
20	*32*	*32*	*32*
25	*35*	*34*	*34.5*
30	*33*	*32*	*32.5*
35	*31*	*31*	*31*
40	*29*	*29*	*29*

Examiner's comments

Marks awarded 4

A typical skill required at AS is to be able to draw a table. The table shown achieved full marks as an A grade answer would be expected to. This table is boxed, correctly headed and contains the necessary units. All measurements and calculations were for the necessary number of significant figures for the experiment, using decimal values when the average was not a whole number.

Q2b(i) Label the axes on the graph, including the units. [1]

Examiner's comments

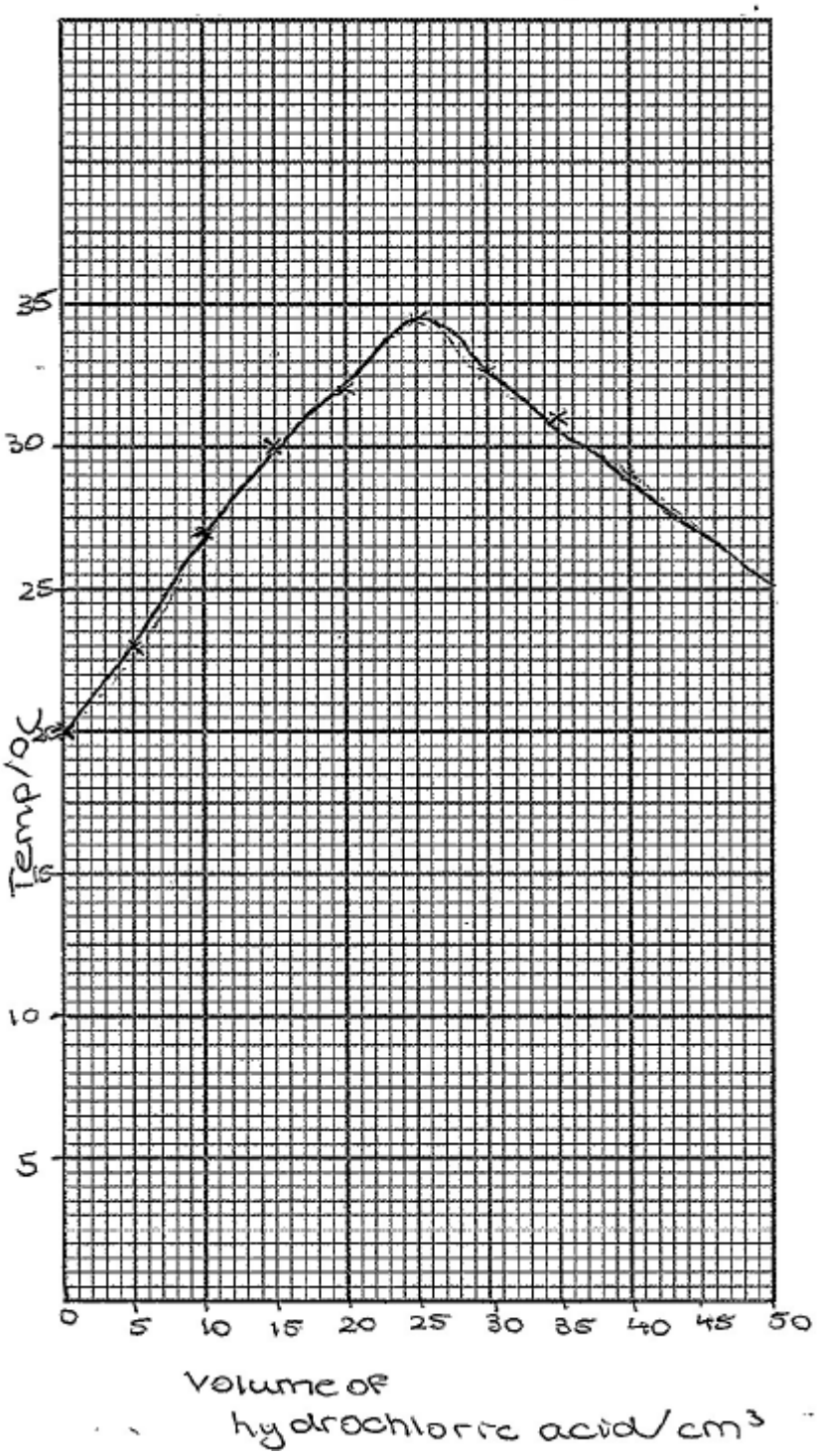
Marks awarded 1

The graph is correctly labelled as would be expected for a grade A response.

Q2b(ii) Plot a graph of mean temperature against volume of hydrochloric acid added. [2]

Student's response

Graph showing the effect on temperature of different volumes of HCl being added to sodium hydroxide solution



Examiner's comments

Marks awarded 2

The candidate has correctly plotted points and joined them in a suitable manner, this correct presentation of data is typical of an A grade answer.

Q3 You are provided with three unknown liquids labelled **E, F** and **G.** Without using any other reagents, give observations for each of the following procedures.

Q3a Describe the smell of each of the liquids.

(i) E [1]

Student's response

Odourless/No characteristic smell

(ii) F [1]

Student's response

Alcohol smell

(iii) G [1]

Student's response

Characteristic sharp smell (petrol-like)

Examiner's comments

Marks awarded 3

This question is again an observation exercise, the smells of E and F were expected to be recognisable, and a typical A grade answer would give very tight, very narrowly defined descriptions just as the answer shown does, G was expected to be less familiar and more general answers were accepted as can be seen by the mark awarded.

Q3b(i) Mix 2 cm^3 of **E** with 2 cm^3 of **F** in a test tube. [1]

Student's response

Colourless solution forms

Q3b(ii) Mix 2 cm^3 of **E** with 2 cm^3 of **G** in a test tube. [1]

Student's response

Colourless solution with 2 layers

Q3b(iii) Mix 2 cm^3 of **F** with 2 cm^3 of **G** in a test tube. [1]

Student's response

2 layers form.

Examiner's comments

Marks awarded 1

Again, this question required very simple observations, this can be seen with the mark awarded for (b)(i). Part (ii) demonstrates how even an A grade candidate can lose marks if they give additional incorrect statements, the reference to solution is incorrect and meant that the available mark could not be obtained for this part. Part (iii) was an incorrect observation which was unfortunate as it was a concise answer with no risk of listing.

Q3c Place 2 drops of **F** and **G** on different watch glasses and ignite using a burning splint.

Q3c(i) **F** [1]

Student's response

Clean blue flame

Q3c(ii) **G** [1]

Student's response

Yellow sooty flame

Examiner's comments

Marks awarded 2

Burning of liquids is a typical AS practical skill. A typical A grade answer is very much like the one shown where the candidate homes in on both the colour and the sootiness of the flame as these are the observations expected as indicators for complete and incomplete combustion.

GCE: AS CHEMISTRY

SCH32 Basic Practical Chemistry Theory Paper

Grade: A Exemplar

Q1 A sample of hydrated sodium carbonate, $Na_2CO_3.xH_2O$, was analysed by titration to determine the amount of water of crystallisation. 2.79 g of the hydrated sodium carbonate were dissolved in 250.0 cm^3 of deionised water. 25.0 cm^3 of this solution were titrated with 0.10 mol dm^{-3} sulfuric acid. The mean titre was 22.5 cm^3.

The following reaction occurred:

$$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$$

Q1a(i) Describe how the 250.0 cm^3 solution of sodium carbonate could be prepared. [4]

Student's response

Weigh in a weighing boat or a balance 2.79 g of hydrated sodium carbonate. In a clean,dry beaker dissolve the sodium carbonate approximately 100 cm^3 of deionised water taking washings from the weighing boat. Using a glass funnel pour the solution into a 250 cm^3 volumetric flask and take washings from the beaker so no solution is left – Fill the rest of the volumetric flask up with deionised water until the bottom of the menicus is on the gradiation mark - stopper the flask and shake to mix the solution

Examiner's comments

Marks awarded 3

This is a known preparation for which specific guidelines are available, hence a lot of detail is required for full marks. This answer included most of the detail, it indicated that a correct amount had been weighed and gave an appropriate volume of water for the dissolving process. Despite being a high-quality answer, a mark was lost due to the omission of the inversion of the volumetric flask at the end of the process.

Q1a(ii) Name a suitable indicator for this titration, and state the colour change at the end point.

Indicator _____

Colour change from _____ to _____ [3]

Student's response

Methyl orange
Yellow red

Examiner's comments

Marks awarded 3

The use of indicators and associated colour changes is a basic AS3 question, a typical A grade response would be expected to give the correct indicator, correct colours and correct sequence as this answer demonstrates.

Q1b Use the following headings to calculate the value of x in the hydrated sodium carbonate. [5]

Student's response

Number of moles of sulfuric acid added

mol = 22.5 x 0.1/1000 = 2.25 x 10^{-3} moles

Number of moles of sodium carbonate in 25.0 cm^3 of solution

1:1 2.25 x 10^{-3} moles

Number of moles of sodium carbonate in 250.0 cm^3 of solution

0.0225 moles

Mass of sodium carbonate in 250.0 cm^3 of solution

0.0225 = 9/106 g = 2.385g

Mass of water in the hydrated sodium carbonate

2.79 – 2.385 = 0.405

Moles of water in the hydrated sodium carbonate

$$mol = \frac{0.405}{18} = 0.0225$$

Value of x

x = 1

Examiner's comments

Marks awarded 4

Calculations, structured and unstructured are important to AS chemistry. A grade candidates typically fare well with structured questions, this is demonstrated here with all but the last step performed correctly, and required units included as necessary.

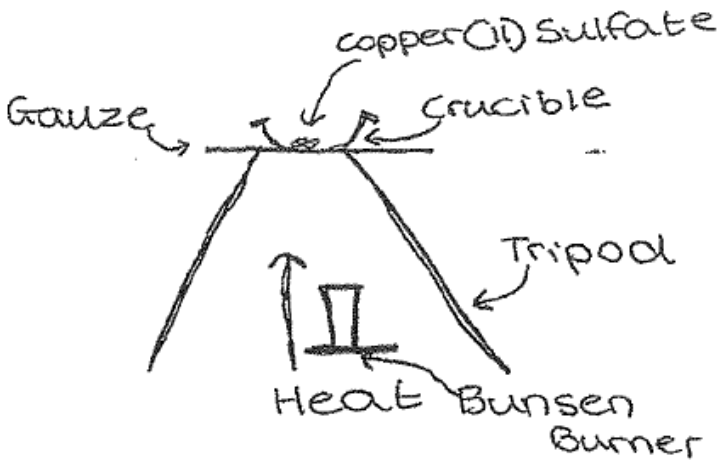
Q1c An alternative method to determine the amount of water of crystallisation in hydrated salts is to heat the hydrated compound in a crucible until it reaches constant mass.

The following masses were obtained using this method.

mass of crucible	11.60 g
mass of crucible + hydrated copper(II) sulfate before heating	16.60 g
mass of crucible + contents after heating for ten minutes	14.93 g
mass of crucible + contents after heating for fifteen minutes	14.93 g

Q1c(i) Draw a labelled diagram of the apparatus used to heat a sample of hydrated copper(II) sulfate. [3]

Student's response



Examiner's comments

Marks awarded 2

The ability to draw arranged apparatus is a necessary practical skill and is regularly assessed. Many candidates struggle to draw apparatus correctly, a consequence being even an A grade candidate may not get full marks for a diagram. In this drawing, the candidate lost a mark because they drew a gauze when the required apparatus was a pipeclay triangle.

Q1c(ii) Outline one safety precaution required when the weighings are taken after heating. [1]

Student's response

Crucible will be very hot – lift with forceps

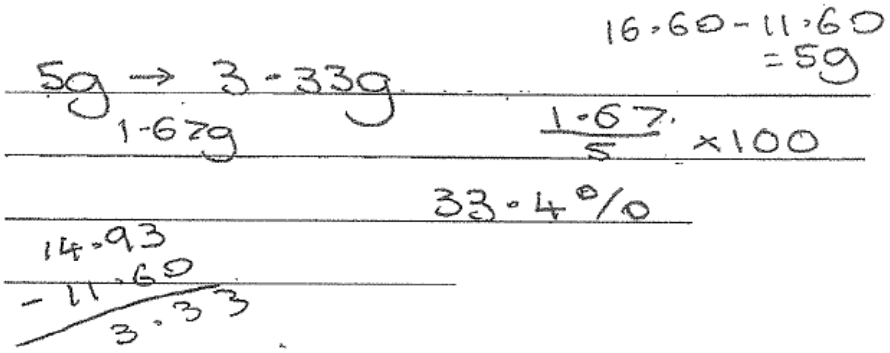
Examiner's comments

Marks awarded 0

Understanding of safety procedures is a key aspect of any practical chemistry course. The required answer, to wait for the apparatus to cool, was often not given even by A Grade candidates. The most common error was the one seen here.

Q1c(iii) Calculate the percentage, by mass, of water in the hydrated copper(II) sulfate. [2]

Student's response



Examiner's comments

Marks awarded 2

The calculation was well performed by almost every A grade candidate, with the vast majority of candidates at this level scoring both of the available marks.

Q2 Propanone may be prepared by the following method:

A solution containing 15 g of sodium dichromate(VI) in 100 cm^3 of dilute sulfuric acid is added dropwise to 11.5 cm^3 of propan-2-ol (density 0.79 g cm^{-3}). This mixture is refluxed for 20 minutes. The apparatus is then rearranged for distillation, collecting the distillate below 60 °C. The distillate is then dried using anhydrous sodium sulfate. A yield of 7.0 g is obtained.

Q2a(i) Define the term **reflux**. [1]

Student's response

repeated boiling and condensing of a reaction mixing

Examiner's comments

Marks awarded 0

Many definitions are expected at AS both simple and more complex. Language is important, in this example the candidate used the word mixing when they meant mixture and did not obtain the mark.

Q2a(ii) Describe, giving practical details, how the distillate is dried and how the sodium sulfate is removed. [3]

Student's response

Add 1g of sodium sulfate to the distillate in a separating funnel and shake until the distillate is colourless. To remove the sodium sulfate, filter it from the product.

Examiner's comments

Marks awarded 2

This question requiring practical detail caused problems to many candidates, this answer gave an incorrect piece of apparatus for the shaking (the separating funnel) so it was not possible to obtain all three marks.

Q2b Calculate the percentage yield of propanone. [3]

Student's response

propan-2-ol mass = 11.5 x 0.79 = 9.085g

sodium dichromate 15g mol = 15/262 = 0.057

moles of C_3H_7OH = 9.085/60 = 0.151

propanone = 0.151 x 58 = 8.758

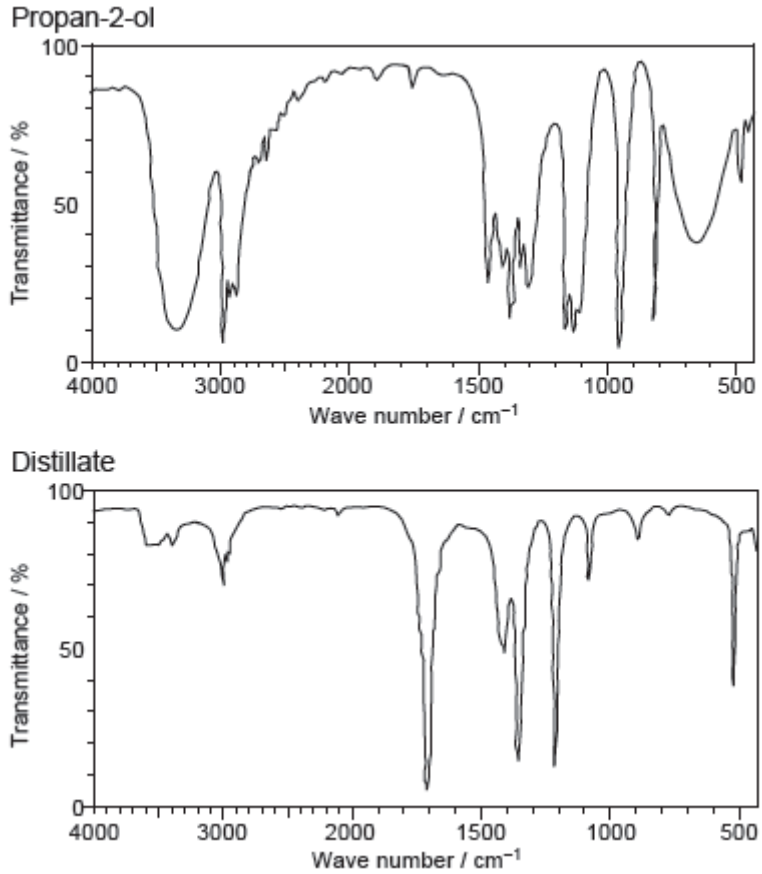
% yield = 7/8.758 x 100 = 79.93
= 80%

Examiner's comments

Marks awarded 3

This is an example of an unstructured calculation and a typical A grade response was able to obtain all three marks by working through the calculation logically and correctly. This can be seen in the response shown.

Q2c The infrared spectra for propan-2-ol and the distillate are shown below:



Explain, through the identification of specific functional groups and their peaks, what evidence there is in the spectra showing that propan-2-ol has been completely converted into propanone. [3]

Student's response

theres a peak in propan-2-ol for OH at around 3000 – 3500 and there isnt on the distillate graph. Theres a peak for C=O on the distillate graph.

Examiner's comments

Marks awarded 2

In this data analysis question, even A grade candidates missed key details, this is evident in the response shown where the candidate did not give the position of where the C=O peak would be expected to be found. Apart from that omission the answer was detailed giving the position of the -OH peak and indicating correctly in which spectra it could be found.

Q2d Suggest why reflux would not be suitable in the preparation of propanal from propan-1-ol. [1]

Student's response

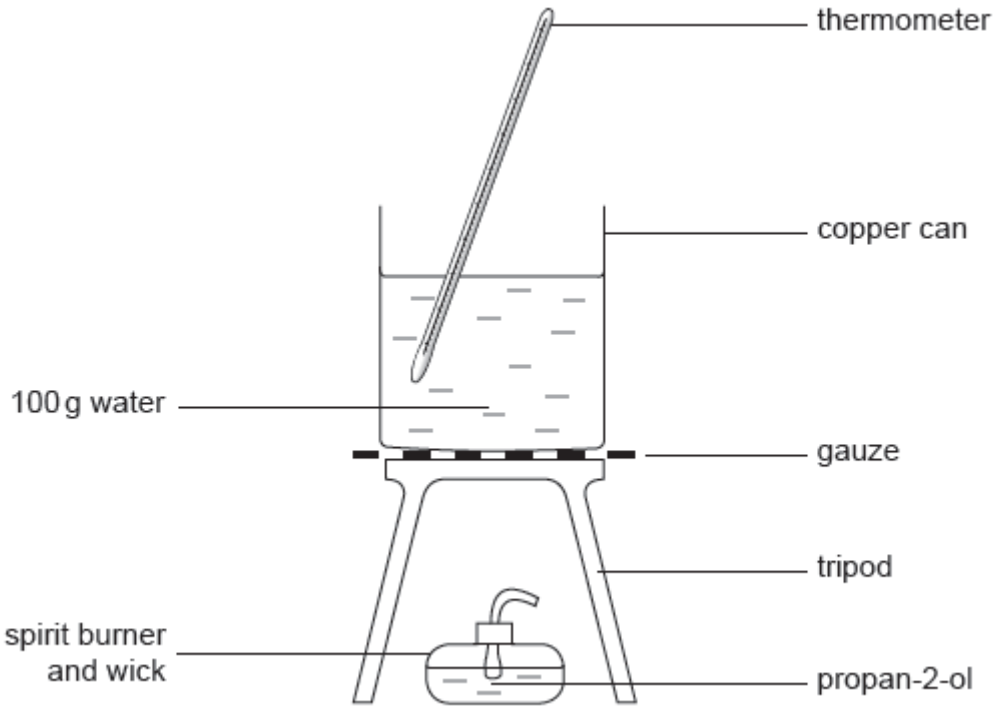
it would keep refluxing to a carboxlic acid

Examiner's comments

Marks awarded 1

This is a simple question with a straightforward answer. The correct answer shown focusses on the consequences of using an aldehyde.

Q3 The enthalpy of combustion of propan-2-ol, C_3H_8O, can be determined using the apparatus shown below.



Q3a(i) Define the term **enthalpy of combustion**. [2]

Student's response

The enthalpy change when one mole of a substance is completely burnt in oxygen under standard conditions.

Examiner's comments

Marks awarded 2

This is another definition which the candidate has this time answered correctly in the correct language.

Q3a(ii) Write an equation for the complete combustion of propan-2-ol. [2]

Student's response

$C_3H_8O + 5O_2 \rightarrow 3CO_2 + 4H_2O$

Examiner's comments

Marks awarded 1

In chemical equations, it is expected that candidates give correct formulae for reactants and products, this candidate has done that, but they have lost a mark because they did not balance it correctly.

Q3a(iii) Why is a copper can used? [1]

Student's response

It is good at absorbing the heat from the spirit burner.

Examiner's comments

Marks awarded 0

This question on practical detail required a precise answer, the response did not indicate that the heat was conducted (to the water) so the mark was not obtained.

Q3a(iv) Why should the water be stirred throughout the experiment? [1]

Student's response

To make the water approximately the same temperature everywhere.

Examiner's comments

Marks awarded 1

This question again asked about practical detail and in this case a correct reason was given precisely enough to obtain the mark.

Q3b(i) When completely burned, 0.60 g of propan-2-ol caused 100 g of water to increase in temperature by 36 °C. Calculate the enthalpy of combustion of propan-2-ol. The heat capacity of water is 4.2 J g^{-1} K^{-1}. [3]

Student's response

$q = mc\Delta T$
$q = 100 \times 4.2 \times 36$
$q = -15120\ J\ mol^{-1}$
$q = -15.12\ KJ\ mol^{-1}$
$moles = \frac{0.6}{60} = 0.1\ moles$

$\frac{-15.12}{0.1} = -151.2\ KJ\ mol^{-1}$

Examiner's comments

Marks awarded 2

This is another unstructured calculation. The candidate has mostly worked correctly and given the correct units and sign, however the final answer is out by a factor of ten because the initial calculation for q was not performed correctly. A mark was lost in this step but the incorrect answer (-15120 J mol^{-1}) was carried through for the rest of the calculation.

Q3b(ii) A data book gives the enthalpy of combustion as –2006 kJ mol^{-1}. Suggest a reason why this value differs from the value found in **(b)(i)**. [1]

Student's response

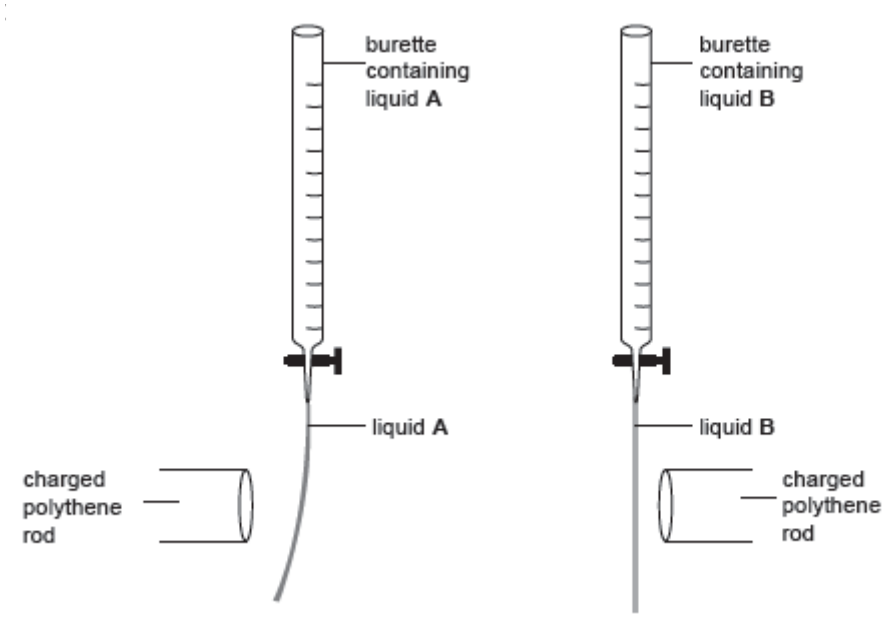
Heat may have been lost to the surroundings.

Examiner's comments

Marks awarded 1

This question about issues with practical measurements would be expected to be well known and this response is correct as would be expected.

Q4 An experiment was carried out to test for polarity in the molecules of two liquids, **A** and **B**.



Q4a Explain the difference in the results observed. [2]

Student's response

A deflects towards the rod as A must be polar and may contain OH groups so its attracted to the rod. B is non polar and may not contain OH groups.

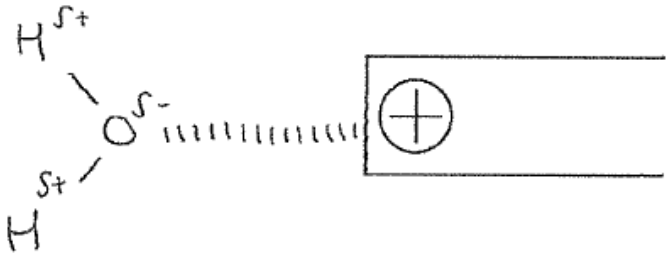
Examiner's comments

Marks awarded 2

This question about the deflection of polar liquids is taken from the specification, a typical A grade response such as that shown tended to match the mark scheme very closely.

Q4b Complete the diagram to show how a molecule of water is attracted to the charged rod shown below. [1]

Student's response

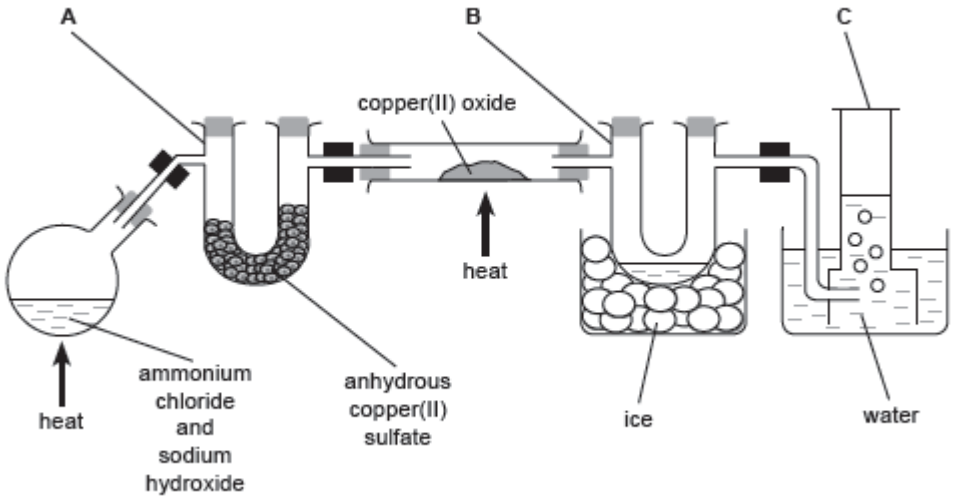


Examiner's comments

Marks awarded 1

The diagram produced for this question needed to show all partial charges and be orientated correctly. The response shown is a typical A grade answer and included all necessary details.

Q5 The apparatus below was set up to investigate the reduction of copper(II) oxide by ammonia gas.



Q5a Suggest an equation for the reaction between ammonium chloride and sodium hydroxide to form ammonia. [1]

Student's response

$NH_4Cl + NaOH \rightarrow NH_3 + NaCl + H_2O$

Examiner's comments

Marks awarded 1

This question required a chemical equation for which the reactants and products were specified and tended to be answered exactly as shown.

Q5b Name the piece of apparatus labelled **A**. [1]

Student's response

u-tube

Examiner's comments

Marks awarded 1

This piece of apparatus was not familiar to all candidates but again a typical A grade answer identified it correctly as shown.

Q5c State the purpose of the anhydrous copper(II) sulfate in **A**. [1]

Student's response

To remove water/Drying agent.

Examiner's comments

Marks awarded 1

The correct reason for adding copper sulfate was almost universally known, being familiar chemistry from KS3 and KS4.

Q5d What will be observed in **A** during the experiment? [1]

Student's response

Blue colour forms

Examiner's comments

Marks awarded 0

The response shown is an example of how if a piece of key information is missing the mark is not awarded. The candidate has not identified that it is the solid which turns blue and does not receive the mark.

Q5e The solution that collects in **B** turns Universal Indicator blue. Explain what causes this change. [2]

Student's response

Ammonia is alkali and turns Universal indicator blue

Examiner's comments

Marks awarded 2

This part proved challenging but the question was only open to a very narrowly defined response. This response meets the mark scheme almost exactly.

Q5f The gas collected in **C** is a product of the reduction of the copper(II) oxide. Suggest the name of this gas. [1]

Student's response

Oxygen
$2CuO \rightarrow 2Cu + O_2$

Examiner's comments

Marks awarded 1

This part was the most challenging question on the paper. To answer correctly the candidate needed to think about how ammonia would react with copper oxide. Clues were provided through the fact that the reaction is identified as a reduction, furthermore the presence of the second U-tube in the diagram should have also been a clue that water was one of the products from this reduction. Despite this, only a tiny minority of candidates identified the correct answer and many A grade candidates did not.

Q6 Calcium carbonate is used in toothpastes as an abrasive. Describe, giving practical details, how laboratory tests can be performed to identify the ions in a sample of calcium carbonate and state the expected results.

calcium ion [3]

Student's response

Using a flame Test. Dip Nichrome wire in conc. Hydrochloric acid, then dip into the sample. Place in a Blue Bunsen flame. Brick Red flame shows calcium ions present.

carbonate ion [3]

Student's response

Add hydrochloric acid to the sample. Collect the gas given off and bubble it through Limewater causing it to turn from colourless → cloudy which confirms carbonate ion present.

Examiner's comments

Marks awarded 6

This question required the description of two chemical tests which were taken from the specification. A typical A grade answer is precise and contains practical detail. The answer shown is detailed and includes all necessary information. In the test for the calcium ion the hydrochloric acid was described as concentrated, which is necessary for this chemical test. In the part referring to the carbonate ion, the acid was named as would be expected in a question requiring practical detail, these details are often missed by many candidates but are typical of a grade A answer.

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