GCE EXAMINERS' REPORTS

GCE (NEW)
CHEMISTRY
AS/Advanced

SUMMER 2018

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CHEMISTRY

General Certificate of Education (New)

Summer 2018

Advanced Subsidiary/Advanced

UNIT 1

General Comments

The mean mark was 33.4 (up 2 marks from last year), the highest mark 75 and the lowest 1. In Section B the most successfully answered question as a whole was Q.10 with Q.11 being the least successfully answered. The most accessible parts on the entire paper proved to be Q.4(a), Q.8(a)(i) and Q.1, while the most challenging parts were Q.7(a)(iii), Q.11(b)(ii) and Q.8(e) in that order.

The examiners were disappointed with the standard of many of the answers given, especially the QER question. As noted in last year's report, more marks are lost for shortcomings in basic recall than in dealing with data given in new situations. Candidates are once again advised to read the questions carefully, so that their answers are what is actually required.

It was pleasing to note that good knowledge of the test for halides, radioactivity and equilibrium constants was shown by a significant number of candidates. Also there was a distinct improvement in dot and cross diagrams.

Once again a significant number of candidates performed well in many familiar calculation questions e.g. Q8(b)(ii), Q9(f)(i), Q10(b). However, the calculations that were different were poorly answered e.g. Q8(c), Q9(e). This shows that candidates' understanding of numerical concepts is lacking in depth. Many candidates still have a difficulty in converting from one unit of measurement to another and changing the subject of a formula.

Although bonding is a staple GCSE topic, the questions on type of structure [Q11(b)] and the relationship between physical properties and bonding [Q7(a)] were very poorly answered. It is apparent that many have made little progress in understanding from GCSE level.

Other areas that still need improvement are precipitation reactions of Group 2 ions, ionic equations and redox reactions.

Atebion Cyfrwng Cymraeg

Safodd tua 7% o'r ymgeiswyr y papur trwy gyfrwng y Gymraeg. Nid oedd llawer o wahaniaeth rhwng y papurau Cymraeg a'r papurau Saesneg, er ar y cyfan roedd safon atebion y papurau Saeneg ychydig yn well. Roedd safon atebion Adran A a'r cwestiynau mathemategol yn debyg iawn. Mi roedd y mwyafrif o atebion anghywir yn dilyn yr un patrwm a'r canolfannau Saesneg. Nodwyd bod canran uwch o'r ymgeiswyr cyfrwng Cymraeg yn gadael atebion allan yn gyfangwbl os oedd ansicrwydd am yr ateb.
Roedd ymgeiswyr yn defnyddio'r termau Cymraeg yn hyderus mewn gwaith estynedig a gwelwyd iaith raenus mewn llawer o'r atebion hirach, fel egluro tymereddau ymdoddi Grŵp 7 a dewis isotop ymbelydrol addas. Nid oedd yn ymddangos bod iaith y cwestiynau wedi achosi unrhyw anhawster i'r ymgeiswyr. Yn hytrach, fel yn y papurau cyfrwng Saesneg, mae llawer o ymgeiswyr yn colli marciau trwy flerwch neu oherwydd eu bod heb ddeall egwyddorion yn ddigon trylwyr.

Section A

This section was fairly well answered, with the mean mark being just under 6 out of 10.

Q.1 Although 8 is the correct coordination number, 8:8 was also accepted so around two thirds gained the mark. Some lost a mark for giving the coordination number of the chloride in sodium chloride, others gave the oxidation number of the chloride ion.

Q.2 Again around two thirds correctly stated that the element was in Group 2.

Q.3 More than half the candidates gained the mark but $3d^4$ $4s^2$ and $3d^6$ were frequently seen.

Q.4 (a) Very well answered. Almost all correctly balanced the equation.

(b) Only about half the candidates gave the correct atom economy. The main error was to use the molar mass of one water molecule rather than five leading to an answer of 43.4%.

Q.5 (a) Less than half could give an adequate description of electronegativity. Too many candidates did not make it clear that the electrons were in a shared pair or in a covalent bond.

(b) Again less than half the candidates managed to adequately explain why electronegativity increases across a period. A significant minority focused on electrons instead of the nucleus.

Q.6 (a) Poorly answered. Only about a third could write a correct ionic equation. A minority failed to balance the equation or omitted charge, but many did not know where to start.

(b) Generally well answered, with just under two thirds giving a correct answer. The vast majority should have gained this mark but many thought that the precipitate would be white.

Section B

Q.7 (a) (i) Whilst around two fifths of candidates gained at least 2 marks out of 3, around two fifths failed to gain any marks. Many recognised that iodine had stronger (or more) van der Waals forces and so more energy was required to break the forces. However, fewer explained this in terms of iodine having more electrons. Others lost marks for confusing intramolecular and intermolecular bonding.

(ii) Poorly answered. Only around a quarter gained the mark. Many lost the mark by referring to the cation charge without mentioning the valence electrons. Some simply stated that “the intermolecular bonds were stronger in Al”.

(iii) This proved to be the most poorly answered question on the paper with the vast majority failing to score a mark. Surprisingly only a few candidates knew that silicon has a giant molecular structure. A few failed to compare silicon with phosphorus but many irrelevant answers regarding ionisation energy were seen.

(b) About half the candidates failed to gain a mark. Some incorrectly thought that the first ionisation energy of oxygen was greater. Many lost a mark because they concentrated too much on oxygen and consequently lacked the depth of comparison needed for the two marks.

(c) There were many two mark answers in this isotopic mass calculation. However, there were an equal number gaining no marks with 60.93 being a common answer despite its impossibility as the average of 121 and 123 cannot lie outside these limits.

(d) The majority correctly identified ^{99}Tc as the most appropriate radioactive tracer giving adequate reasons and so gained a mark. However, to gain further marks they had to use **all** the data (as clearly stated in the question). Since most did not mention the other three isotopes they did not gain any further marks. A significant minority answered that α-radiation in the body is harmless because it is the least ionising and so selected the wrong isotope and gained no marks.

Q.8 (a) (i) Very well answered. The vast majority correctly labelled the line furthest left as A.

(ii) Around half the candidates gained at least 1 mark out of 2. Whilst many identified that energy levels (or the difference between them) are quantised, most failed to discuss excited electrons falling to lower levels and so failed to gain the second mark.

(b) (i) Well over half the candidates scored 1 mark, but only a few scored 2. The majority gave the definition of molar ionisation energy and so lost a mark. The minority who explained in terms of a single atom tended to omit reference to the gaseous state and so lost a mark.

(ii) Well answered with almost three quarters scoring at least 2 out of 3 marks in this calculation on frequency. The main errors were a failure to convert kJ into J and using Avogadro’s constant as well as Planck’s constant.

(c) Over half the candidates correctly used $V_1/T_1 = V_2/T_2$ to calculate the volume. However, only a minority of these used the gas molar volume to calculate the number of moles to show that the M_r was 32. Most candidates incorrectly used the M_r to calculate the number of moles. A few used $pV = nRT$ twice and gained full credit, though this is rather a laborious method.

(d) (i) Some unusual electron arrangements for hydrazine were seen but generally this question was well attempted with over half getting at least one mark and many scoring both.

(ii) Disappointingly answered. Candidates were required to state that the electron pair in such a bond is not shared equally.

(e) A difficult question. Not many could write an equation to show that an unfamiliar base is a proton acceptor.

Q.9 (a) Only fairly well answered. Although around a half scored at least one mark, only about a fifth scored both marks. A number of candidates did not realise that the uncertainty in each reading was 0.0005 g, while others seemed unaware that both the initial and final weighing had to be considered. Another common error was a failure to convert mg to g.

(b) (i) The majority of candidates realised that the volume of water was unimportant, but significantly less than half could explain why. The two most common errors were “water would evaporate when heated” and “water is in excess”.

(ii) Slightly better answered with around a half gaining the mark. Some lost the mark for stating “an increase in the rate of reaction” rather than “an increase in the rate of dissolving”. However, the main error was reference to evaporating the water.

(c) Most candidates gained one mark by calculating the titre from the mean and an answer of 26.79 cm^3 was often seen. However, the vast majority did not realise that burette readings have an uncertainty of ±0.05 cm^3 and gave the final titre reading as 26.99 cm^3 instead of 27.00 cm^3.

(d) Around two thirds gained at least one mark, mainly for recognising that less NaOH would be needed. Fewer were able to explain why and gain the second mark.

(e) This question on percentage of ascorbic acid proved to be difficult. Around two fifths scored all three marks but around a half failed to score any marks. Far too many candidates simply divided the mass of the tablet by the M_r of ascorbic acid and multiplied by 100.

(f) (i) The vast majority correctly used the expression for pH. However, the most common answer was a pH of 2 (rather than 1.7) as the candidates had not realised that sulfuric acid is dibasic so releases two protons on dissociation. This gained one mark.

(ii) This redox question was better attempted this year. However, careless errors were still made e.g.

- confusing oxidation and reduction with respect to oxidation numbers
- oxidation number of Cl changing from −4 to 0
- identifying oxygen or hydrogen as undergoing redox

Q.10 This question was the best answered question in this section.

(a) (i) Due to error carried forward (ECF), the vast majority gained at least 1 mark out of 4. Many different expressions were seen for K_c and the unit mark proved difficult to obtain. Many candidates omitted reference to the significance of the value of K_c and the student's claim.

(ii) A significant number failed to score a mark by stating that the reaction was endothermic. Some lost a mark for referring to “the endothermic side” instead of “the endothermic direction”. Most lost a mark for not explaining why the endothermic direction was favoured.

(b) This maximum mass calculation was well answered with a significant number gaining all three marks. Most candidates changed tonnes into kg not g, but were not penalised. The main errors were using $8NH_3$ to calculate the moles of ammonia and not using the 8:3 ratio correctly to calculate the moles of DAP.

(c) Again a well answered calculation with around half the candidates gaining at least 3 marks out of 4. As expected the main error was a failure to convert m^3 to cm^3. Almost all candidates who attempted the calculation converted °C to K, but surprisingly converting kPa to Pa proved challenging for a significant minority. Some lost a mark for failing to rearrange $pV = nRT$ correctly.

Q.11 This was the least well answered question in this section.

(a) (i) As expected, a whole range of answers was seen in the QER question. Only a small minority of candidates obtained the ‘higher band’ of marks with around half scoring in the ‘lower band’. A significant minority did not attempt the question.

Most candidates could both recall and apply the use of silver nitrate solution in identifying the chloride ions. Significantly fewer chose barium chloride for the sulfate ions and an appropriate acid for the carbonate ions. Indeed, some candidates thought that carbonates turn limewater cloudy!

Many did not read the question properly and assumed that there were three separate solutions, each with a different anion. Others thought that the cations had to be identified and wrote incorrectly about flame tests.

Many candidates did struggle after the silver nitrate test and their answers deteriorated – with many adding Group 2 metals to the solution to precipitate the carbonate or sulfate.

Very few candidates realised that the order in which the tests were carried out, dividing the solution and the type of acid used were all fundamental to the answer.

(ii) While a significant number realised that a flame test could identify sodium, some got the colour wrong. Fewer recognised that all Group 1 salts are soluble so the cation could be any metal from this group.

(b) (i) Most recognised that **C** was metallic (or possibly graphite) and many that **A** was simple molecular and **D** was ionic. However, some stated covalent for **A**, which was not enough to get the mark. Very few stated that **B** was either giant covalent or ionic. Some tried to identify the substance e.g. “**B** must be diamond”, which did not answer the question.

(ii) This was linked to part (i) and was poorly answered. Despite the fact that **B** was insoluble, seeing if it conducted in a solution was a popular test. Another popular incorrect answer was performing a flame test. A number of candidates did not attempt this question.

(iii) Around a third of candidates recognised that a powdered metal made identification of certain properties difficult to illustrate. Marks were lost due to vague answers that did not pinpoint what these properties were. Others focused on the powder making the metal more reactive due to a greater surface area or being soluble in water, which again gained no credit.

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UNIT 2

General Comments

The paper proved generally accessible with candidates being able to demonstrate what they know.

It was pleasing to note that many candidates coped well with questions that demanded the interpretation of data and with calculations. It was however noted that questions designed to allow candidates to demonstrate their **understanding** of practical procedures were less well answered. Teachers are advised that, when practical exercises are undertaken, they ensure that candidates think through the implications of the particular actions carried out.

Most candidates attempted all parts of the paper and there was no evidence that lack of time was a factor in performance. The number of blank responses to the last part of the last question was thought to be due to its difficulty rather than being a time factor.

Section A

1. Most candidates drew an acceptable formula.

2. Although many correct answers were seen, a significant number of candidates drew CH_3 groups on the side chains. Clearly this is not acceptable in a skeletal formula.

3. Most candidates recognised that the significant difference was due to hydrogen bonding. For both marks to be awarded it was necessary to compare the situation in ethane and ethanol and also to state that the hydrogen bonding involved ethanol and water.

4. A wide variety of diagrams showing overlap of the two p-orbitals were credited.

5. Very few correct equations were seen but far more candidates suggested a suitable catalyst.

6. Although a significant number of correct answers were seen many candidates appeared to have difficulty in drawing the structure of a polymer when side groups are involved.

7. A large number of correct answers were seen.

Section B

8. (a) Any suitable method involving measuring with an instrument was accepted. However, a large number of candidates ignored the words 'instrumental method' in the question and suggested the addition of silver nitrate.

   (b) This was generally well done.

   (c) This calculation was generally well done however a significant number of candidates merely used the 2.0g of ethane and the 1.0g of chloroethane to give an answer of 50%.

   (d) A large number of candidates correctly identified butane as being a possible product but far fewer considered the possibility of multichlorination.

   A significant number ignored 'organic product' in the question and suggested chlorine or hydrogen chloride.

9. (a) (i) Most candidates recognised that bond enthalpy is the energy associated with bond breaking or bond making. However, the direction of change, if specified, must be correct. It is therefore not acceptable to state, for example, that it is the energy required to form a bond or the energy released when a bond is broken.

   (ii) This calculation was generally well done with only a small number of candidates reversing the sign of bond breaking and forming or using incorrect multipliers.

   (iii) The diagram was often correct but it should be noted that if single headed arrows are used for E_a and ΔH, they should point in the correct direction.

   (b) Many candidates correctly calculated ΔH but others seemed confused with the direction of the arrows in the diagram.

   (c) A significant number of candidates recognised that the bond enthalpies are different due to their being in different environments. It was not acceptable, in the context of the question, to consider possible errors in practical techniques.

10. (a) (i) This was the question in which the quality of extended response (QER) was assessed. Most candidates linked the variation in bond enthalpy with the rate of hydrolysis. However, although a significant number recognised that the difference in electronegativity meant that permanent dipoles were present, very few commented that the variation in the $\delta+$ on the carbon was actually in the opposite direction to the variation in the rate.

   (ii) It is encouraging to note that responses to questions involving ionic equations have improved.

   (iii) This is an example where it was hoped candidates would recognise the significance of practical exercises that they had carried out. A number did include the idea of obscuring a cross or something similar but many merely said that they would measure the time for a precipitate to appear.

(iv) A really precise answer was only given by the most able although rather vague responses, such as ‘they won’t mix’, were credited. Many answers suggested that the reaction would speed up or slow down.

(b) (i) This was well done although a number of candidates did not gain the mark available for stating that the radical involved is chlorine.

(ii) For full credit it was necessary to identify a specific bond that was too strong to be broken. Many candidates did so.

11. (a) It was pleasing to note that many candidates answered this question using the data provided in a logical manner.

Most used the percentage composition, mass spectrum and IR information correctly – with only occasional mathematical errors. A significant number also stated that it was the different hydrogen **environments** that accounted for the three peaks in the ^{1}H NMR spectrum.

It was however the chemical data that caused most difficulty with only the more able appreciating that the dichromate(VI) test indicated that **X** was a primary or secondary alcohol whilst the product of the oxidation ruled out it being primary.

(b) (i) Most candidates gave an acceptable answer.

(ii) Credit was given for any structure that could be formed by oxidising the compound specified by the candidate as being **X**.

12. (a) This was again based on a practical procedure with which candidates are expected to be familiar and in general it appeared that they could handle the data given.

(i) & (ii) Most rates were calculated and plotted correctly although a number of candidates reversed the plot of rate and concentration.

(iii) Assuming that the graph was a straight line candidates were expected to state that the rate was **proportional** to concentration. It was therefore considered too vague merely to state that the rate increased as the concentration increased.

(iv) Many candidates drew suitable lines on the graph and read the rate from the y-axis. It was however necessary to use this to calculate the time for the second mark. A significant number of candidates did not carry out the second part of the calculation.

(v) Although a number of candidates realised that the reaction slows as it proceeds, only the most able explained the error that this introduces if $\frac{1}{time}$ is used as rate. These candidates showed that they really had considered how practical data are interpreted.

(b) (i) Since this curve is directly specified in the specification, it was a little disappointing to note how many errors were seen. These included reversing the labels on the axes, incorrect labels, not starting the plot at the origin and drawing a line meeting or crossing the x-axis at high energies.

(ii) The significance of catalysts on activation energy was generally well explained.

13. (a) Many candidates clearly knew the significance of carbon neutrality although some apparently thought that plant material produces less carbon dioxide than fossil fuels on combustion.

(b) This question was only answered correctly by a few clearly very able candidates. Impossible answers in part (i) meant that a significant number of candidates did not attempt part (ii).

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Advanced

UNIT 3

General Comments

This was the second unit 3 paper for this new specification and the mean mark showed an increase of approximately 4 marks from that seen in 2017. Candidates appear more confident with the elements that have changed from the legacy specification, such as the increased mathematical demand and the questions focusing on many aspects of Assessment Objective 3. Many short questions, especially those requiring factual or practical skill recall, had the lowest facility factors.

The paper appeared to differentiate well, with the facility factor for part questions ranging from below 20% [questions 6, 9(d)(ii) and 11(c)] to over 80% [questions 8(b)(i), 10(b)(ii) and 10(c)(ii)]. Other questions showed the complete range of marks between these extremes. There was no indication that time was a significant factor in this paper, with 94% attempting the very final part question which is greater than attempted several other part questions throughout the paper. Questions that aimed to differentiate between candidates at the highest grades such as some parts of question 11 and 12 showed a good spread of marks with many of the most able candidates gaining full marks or nearly full marks on the most challenging parts of these questions.

Papurau Cyfrwng Cymraeg

Roedd 122 ymgeisydd wedi cwblhau’r arholiad cyfrwng Cymraeg. Roedd y cwestiynau yn dangos patrwm marciau tebyg i’r papurau Saesneg sydd yn awgrymu eu bod yr un mor hyderus wrth ymateb i’r cwestiynau yn y Gymraeg. Roedd ystod y marciau ychydig yn uwch yn y papurau Cymraeg gyda’r marciau ar rai o’r cwestiynau mwy anodd yn is yn y Gymraeg ond rhai o’r cwestiynau llai anodd yn uwch yn y Gymraeg.

Roedd cywirdeb iaith yn ffactor mewn rhai cwestiynau, ond roedd hyn yn broblem yn y Gymraeg a’r Saesneg. Yng nghwestiwn 8(a) defnyddiwyd ‘bromin’ yn lle ‘bromid’ neu ‘clorin’ yn lle ‘clorid’ mewn nifer o atebion, ond roedd gwallau tebyg yn y papurau Saesneg felly roedd y marciau yn y ddwy iaith yn debyg i’w gilydd.

Section A

1. Most candidates were able to write this electronic structure. A few did not realise that copper was one of the two exceptions to the Aufbau principle and placed two electrons in the 4s sub-shell.

2. This was a pure recall question and was answered poorly. There were a range of improbable answers containing a mixture of ligands as well as suggestions that chromate(VI) or dichromate(VI) could form. The most common answers were $Cr(OH)_3$ and $[Cr(OH)_4]^-$. Only a quarter of candidates could correctly give the ion (or an appropriate salt of the ion).

3. (a) A small majority of candidates could identify the correct products when chlorine reacts with sodium hydroxide, but not all of these gained marks as many did not balance their equations and some ignored the stated conditions and gave NaCl and NaOCl as the products.

   Seeing equations that are not balanced, and in some cases where there has been no attempt to balance, in an A-level paper is very disappointing.

   (b) Good answers here expressed the meaning clearly, with the best candidates illustrating their answer with reference to the equation in part (a), although this was not needed for the mark. A lack of clarity in terminology, or perhaps a lack of understanding was often evident. Terms such as the ‘same molecule’, ‘same compound’ or ‘same species’ were used interchangeably with the correct ‘same element’ and did not gain the mark.

4. There are many observations during this reaction and weaker candidates perhaps guessed at common observations they recall from the course such as ‘fizzing’ or ‘white precipitate’. These alone were not sufficient for the mark, however it is pleasing to see that many gave more detail such as reference to the steamy fumes of HCl released.

5. Common errors here were using I rather than I_2 to calculate the M_r to be used, or not to use an M_r at all. Answers given in mol dm^{-3} gained partial credit.

6. Few candidates gained this mark and this proved to have one of the lowest facility factors of any question on the paper. Very many answers referred to enthalpy change of hydration being greater than lattice breaking enthalpy. This either ignores the enthalpy change of solution in the question or shows a lack of understanding of what is meant by enthalpy change of solution. Most candidates who knew that entropy should also be considered gave good explanations.

7. Most gave a reasonable pH value and the range accepted was wide, although pH values of 0 or 1 (as well as alkaline ones) were still seen. The reason was generally given as ‘strong acid with weak base gives acidic salt’ which shows a lack of understanding of why the salt is acidic. Some candidates were not clear in their explanations using terms such as ‘the salt releases H^{+}’ or ‘the salt dissociates’ rather than focussing on the ammonium ion.

Section B

8. (a) There were many good answers here and many poor ones, with fewer marks in between. The observations were recalled by many, although an occasional comment such as ‘bromine is an orange SOLID’ was assigned to exam pressure rather than lack of understanding! The reasons for the differences were often poorly explained with incorrect terminology (e.g. bromine is a strong reducing agent) hindering some. Many compared chloride and bromide but did not link this to the ability to reduce the sulfur in the sulfuric acid.

(b) (i) Most gained this mark, although a few answers gave $[H^+]^2$ as the numerator in the expression.

(ii) This was well answered with most able to calculate the pH of a weak acid.

(iii) There were many vague answers here regarding what an indicator is. Many candidates did not consider the weak acid-strong base titration and others did not refer to the vertical region of the titration curve being in the alkaline region.

(iv) I This was very poorly answered. Most candidates did not realise that the buffer solution created contained sodium fluoride. There were many answers discussing partial dissociation of NaOH and OH^- ions from this reacting with added acid.

II The candidates that realised that the concentration of acid equalled that of salt were able to undertake this calculation. There were many elaborate and incorrect calculations of concentration of both acid and salt by other candidates.

9. (a) Most gained these marks. The most common errors were to draw diagrams without any indication of the third dimension, and to draw bonds to the H in water or ammonia. A surprising large minority wrote water as O_2H.

(b) Most could gain at least two marks here. A small number discussed light being emitted rather than absorbed and were penalised for this.

(c) This question gave a range of marks. Most realised that a white precipitate would be formed, although a few gave a range of incorrect reasons for this. Fewer noted the expected colour change, however most that noted this included the correct explanation. Some candidates gave a colour change to purple noting that some of the aqua complex would be formed in the presence of remaining chloro complex, and this was accepted.

(d) (i) Most candidates gained some marks here and the full range was seen. Many did not include Avodagro’s constant in their calculations and were penalised for this. Many wrong answers were the correct figure given to an incorrect power of ten due to incorrect use (or no use) of the 10^{-9} power for the nm and the 10^3 for kJ.

(ii) This was the part question with the lowest facility factor on the paper. An overwhelming majority gave answers of approximately 590 nm, with many also suggesting 750-800 nm. The concept that using colorimetry, or any other spectroscopic method, requires a frequency absorbed by one species but not the other is a key part of planning an experiment.

(iii) Most gained these marks and where marks were lost these tended to be on the unit rather than the K_c expression.

(iv) The mean mark for this challenging calculation was very close to half marks. It was pleasing to see many able to find the concentration of the chloro complex, however the concentrations of the chloride ions and the aqua complex were more challenging. A small number of candidates attained the full set of concentrations but could not calculate the value of K_c.

10. (a) (i) Most realised that the inert pair effect was the reason behind the differences in the elements, although some referred to one element only or neither. Answers such as 'they are different due to the inert pair effect' lacked sufficient detail to gain the mark.

(ii) This was poorly answered with many answers including $PbCl_4$, PbO or HCl as products. Many others did not list H_2O amongst the products leading to unbalanced equations.

(b) (i) The orders with respect to Fe^{3+} and Sn^{2+} were found by many, but fewer found the order with respect to H^+. Overall this question differentiated well.

(ii) This was answered well and responses were frequently credited using error carried forward from an incorrect answer to part (i).

(iii) Candidates generally gained both marks or neither here, with about half gaining both marks. There were many misconceptions, such as statements that the step suggested would be too fast or too slow, or that it was not possible as it did not give the same products as the overall equation.

(c) (i) This question required the meaning of both sampling and quenching. Some candidates gave one only and so did not gain the mark. Like all methods of measuring rates, answers that did not include reference to time did not gain credit.

(ii) This was well answered and most candidates gained both marks. The most common error was to forget the 1:5 reacting ratio or to apply it in the wrong direction.

11. (a) About two thirds of candidates drew the graph correctly. Those that did not either did not have the same initial or final energy or did not use the activation energy given to plot the correct peak.

(b) (i) Most could state the correct expression for the Arrhenius equation.

(ii) This was well answered although some candidates struggled with units and did not convert activation energy from J mol^{-1}. A few did not state their conclusion.

(c) Fewer than one candidate in five gained the marks here. The question referred to using the graph but despite this many candidates did not take values from the graph. Where values were taken from the graph many used the activation energy of the forward or reverse reaction rather than the enthalpy change.

(d) Most could link the entropy change to the production of a gas from a reaction in solution.

(e) (i) Most candidates could label and give the functions of the parts of the electrochemical cell. Fewer were able to correctly link Le Chatelier's principle to the effect of changing concentrations on the EMF of an electrochemical cell.

(ii) Most could attempt to combine half-equations but a significant minority did not cancel the H^+ ions and H_2O when constructing their equations. The majority could then use the standard electrochemical values to predict if the process was feasible.

A wide range of answers and reasons were given when candidates compared electrochemical and Gibbs free energy methods for finding feasibility. Only a minority noted that the physical state was the key factor. Many discussed which was easier to measure or stated that there were fewer values to use in electrochemical methods so less likelihood of error.

12. (a) This question was poorly answered. Many candidates suggested the names of cations present in **D** and **E** rather than anions, whilst others suggested two different anions despite the question asking for the 'anion' rather than 'anions'. Those candidates that did suggest a single anion gave a range of answers with chloride being one of the most popular. Almost all who gave carbonate (or hydrogencarbonate) as an answer could give a clear reason.

(b) This question was designed to differentiate between the candidates aiming for the highest grades, whilst allowing most to gain some credit. The best answers were a pleasure to read and some weaker answers showed that candidates had learnt some of their chemical tests. Overall, very few candidates did not attempt this question and the full range of marks were seen.

The strongest candidates focused their answers on the unique observations of the bright yellow precipitate, brown solution with a white solid and blue solution. These observations alone allowed them to identify the cations present in **A** and **C** and the anion present in **B**. The flame tests and solubility/reaction with acid allowed the majority of the remaining anions and cations to be identified.

Mid-range candidates stated what some observations represented and started to use these to identify some of the anions and cations present. Typically these candidates correctly identified four or five of the eight remaining unknown ions. [The carbonate ions in **D** and **E** were identified in part (i) of the question.]

Weaker candidates either identified a small number of ions or simply listed what each observation represented, such as linking each flame colour to an ion and stating that the bright yellow precipitate was lead iodide without linking these to conclusions.

The weakest candidates did not recall tests correctly or made incorrect assumptions. Many of these assigned the ions from flame tests to specific compounds without justifying this link e.g. lilac flame test means potassium so compound **A** must contain potassium.

CHEMISTRY

General Certificate of Education (New)

Summer 2018

Advanced

UNIT 4

General Comments

This was the second Unit 4 paper and it is clear that candidates are becoming accustomed to the more challenging aspects of some of the questions. As reported last year, there are now fewer questions that require simple recall and an increase in the number of questions that need a measure of application. There continue to be questions based on the practical side of the work.

This 80 mark paper was designed to take one and three quarter hours and there was little evidence that candidates had been rushed to finish the paper, even though more reading has been introduced.

Some excellent work was seen again this year with evidence of careful revision. Again, some of the weaker candidates clearly had to resort to guessing what the particular reagent required might be for some of the reactions – particularly in a reaction sequence.

The examiners hoped that the paper provided candidates with an opportunity to show what they had learnt and understood in the two years of the course and that they were able to apply their knowledge of the course in unfamiliar situations.

Section A

1. (a) The product of the reaction between benzaldehyde and hydrogen cyanide provided an easy mark for nearly all candidates. A few candidates spoilt their answer by giving another product, or by giving the formula of the aldehyde group as –COH, instead of –CHO.

   (b) The question asked for the formula of the **nucleophile** that took part in the reaction in part (a). The formula of the cyanide ion needed the negative charge to be shown.

   Some candidates gave KCN or HCN as their answer, which is not the nucleophile.

2. The commonest correct answer to this question was butanoic acid. Some candidates did not realise that in a decarboxylation reaction, the alkane product contains one less carbon atom than the starting carboxylic acid.

3. Although many candidates correctly worked out the relative molecular mass to be 130, quite a few then lost the second mark by not correctly identifying the alkyl group as C_3H_6.

   Some candidates did not notice the molar ratio shown in the equation and then struggled to obtain any marks at all.

4. (a) The formula of the ion formed from phenylalanine in basic solution was generally given correctly.

   (b) A number of candidates did not appreciate the ionic nature of the zwitterion structure of 2-aminopropanoic acid and attributed the higher melting temperature of the amino acid to hydrogen bonding.

5. A number of candidates lost marks in this question by neglecting to divide by 9, or dividing by 3 instead. Some credit was given for the resulting answers of 7254g or 2418g. Some candidates obtained the correct answer but did not report it to the appropriate number of significant figures – three in this case.

Section B

6. (a) (i) The correct answer, $C_8H_{16}O$, was generally seen but $C_8H_{15}OH$ was also accepted.

   (ii) Most candidates stated that sodium hydroxide(aq) would hydrolyse 2-bromo-octan-3-ol and that this reaction was an example of nucleophilic substitution.

   (iii) Nearly all candidates stated an appropriate reagent for the subsequent oxidation of octane-2,3-diol to the dione.

   (b) (i) The correct formula for the yellow precipitate was CHI_3. It was surprising how many candidates got this answer wrong; the commonest error was to write CH_3I.

   (ii) Most candidates realised that the groups $CH_3C{=}O$ or $CH_3CH(OH)$ need to be present to produce CHI_3. The formula of octan-2-one was the commonest correct answer but the formulae of appropriate unsaturated alcohols were also accepted.

   (c) (i) The reducing agent was generally correct, with $NaBH_4$ being most commonly seen.

   (ii) Most candidates described the use of a colorimeter which gained the mark. If they described monitoring the colour change some reference to time was also required.

   (d) Many correct answers were seen. It was necessary to indicate a positive charge on the fragments to gain both marks.

   (e) (i) Although most students managed to draw the skeletal formula of the 18 carbon alkyl chain for the first mark, some forgot to provide a primary alcohol group in order to gain the second mark.

   (ii) This was generally correct but some candidates gave sodium tetrahydridoborate(III) as a suitable reagent to reduce the carboxylic acid. A few students incorrectly read the question and gave an oxidising agent instead.

7. (a) (i) The mechanism for this nitration was done poorly by a surprising number of candidates. Common errors included the unclear depiction of curly arrows, omitting the positive charge in the formula of the intermediate, giving a complete circle in the intermediate's formula and forgetting that the intermediate contained a chlorine atom.

(ii) Almost all students knew that this nitration was an example of electrophilic substitution.

(b) Students generally understood the basic ability of the lone pair of electrons on the nitrogen atom to accept protons.

(c) (i) Many candidates could recall that 2,4-DNPH gave a yellow/orange/red solid. Some gave the colour of the product but did not state that it was a solid.

(ii) Some candidates did not realise that this question was focused on the suitable and specific melting temperatures of the derivatives rather than the identification of a carbonyl group.

(d) This question about recrystallisation proved to be a good discriminator with a wide range of marks being seen. Good candidates offered a detailed and safe procedure to recrystallise the product. Some candidates gave a confused account of trying to evaporate off the methanol present!

(e) There were three marks for this question, which asked candidates to describe differences in the infrared spectra of the oxime and its rearrangement product. There were clear differences in the functional groups present. In each case it was necessary to comment on the bond, its absorption value and its presence or absence in each compound. Not all candidates followed this procedure and lost some credit as a result.

8. (a) Not every candidate started with chlorotrifluoromethane and, as a result, lost the mark. The question did not request propagation stages and these were not credited. A number of candidates missed the radical 'dot' and provided anions and cations.

(b) (i) Most candidates interpreted the information provided correctly and gained the mark.

(ii) Some candidates lost marks due to errors in intermediate stages e.g. an incorrect M_r or not using the percentage yield stated.

(c) (i) & (ii) These were both well attempted and many gained both marks. Some lost marks for lack of clarity or careless errors.

(iii) Few candidates managed to get both marks. Many gained the first mark for distillation but could not describe how this was to be carried out. Since both compounds are gaseous at room temperature, initial cooling to below their boiling temperatures was needed before warming the mixture.

(d) (i) Candidates were required to comment on each carbon atom of the double bond being bonded to different groups. Many just focused on the lack of rotation and this was not credited.

(ii) I Nearly all candidates recognised that this was an addition reaction.

II Very few candidates realised that the two carbocations must have ‘equal’ stability. Some failed to read the question carefully enough and included reference to racemic mixtures in their answers.

(iii) This was quite well done but some candidates gave the same structure twice and therefore gained only one mark.

(iv) The 3-D structures were often correct but some were drawn poorly and some gave the same structure twice.

9. (a) The quality of extended response (QER) was assessed in this question. The question proved to be a good discriminator, with a wide range of answers being seen. Most recognised the test for a carboxylic acid and could relate the NMR spectra to the molecule provided – and these tended to be in the 1-2 mark band. Those candidates who were able to develop inferences from the numerical data provided and use most of the qualitative tests scored in the 3-4 mark band. Quite a few scored top band marks for competently interpreting the numerical data with concise and clear calculations, interpreting the qualitative tests and breaking down the NMR data in detail, as well as suggesting that the most appropriate method of definitive identification was the melting temperature.

(b) (i) The question asked for the equation for hydrolysis of methyl ethanoate by aqueous sodium hydroxide. A number of common errors were noted.

- the use of water rather than NaOH
- using ethyl ethanoate
- omitting methanol as a product
- giving the acid as a product, rather than the sodium salt

(ii) I The correct answer for the M_r (88) was an easy mark for almost all candidates.

II The question stated that the compound was an ester and that it reacted with Tollens’ reagent. It must therefore contain an aldehyde group and have a relative molecular mass of 88. A number of candidates could not give the formula of an ester that had all these features.

(iii) Many obtained the correct percentage but could not then go on to explain in part II that mass and the number of moles are only directly related for compounds with the same relative molecular mass.

(iv) It proved difficult for many candidates to gain the mark in this question. The relationship between intermolecular forces and boiling temperature was not always clearly stated.

(v) Many candidates gained this mark by stating that the name of the product was 2-methylbut-1-ene.

10. (a) This question was not well answered. Many candidates found it difficult to put together a sequence of reactions in a synthesis. Some managed the last mark for the reduction and used lithium tetrahydridoaluminate(III). For stages 1 and 2, even if the reagent was correct then the product was often wrong and vice versa.

(b) (i) Although many candidates gained this mark some provided the conditions rather than the reagents. If sodium nitrate was given as a reactant, then its correct oxidation number was needed for the mark.

(ii) A number of errors were noted in the responses to this question. It was common to see HCl omitted and for the azo dye to have a triple bond between the nitrogen atoms.

(c) Few candidates realised that the sodium hydroxide would react with the HCl formed and therefore move the position of equilibrium to the right, increasing the yield. Many candidates wrote that the NaOH reacted with the acid chloride although the question stated that this did not happen!

(d) This was quite well answered by many candidates and for those who made errors, a number gained credit by error carried forward (ECF). A method that used the ideal gas equation was acceptable but unit errors crept in for some of those who took this route.

(e) (i) The systematic naming of a compound that contained two carboxylic acid groups proved difficult for many candidates.

(ii) Candidates were asked to describe the high resolution ^{1}H NMR spectrum of polyester **E**.

Whilst most candidates recognised that the $—CH$ and $—CH_3$ groups would give a quartet and a doublet respectively and got 2 marks, many thought that the $—CH_2—CH_2—$ group would give rise to a triplet, so lost this mark. Nearly all who attempted this question got some credit.

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UNIT 5

Experimental Task

Recording of Results

Part A

The two tables illustrating the results of both titrations were very well constructed overall, with the majority of candidates gaining at least 4 out of a possible 5 marks. Common errors tended to stem from:

- missing units
- 1 rather than 2 decimal places
- incorrect subtraction of initial from final volume readings
- selection of non-concordant titres

For the accuracy of the mean titres obtained, all marks from 0 to 6 were seen but most candidates attained at least 2 out of 6 for this section.

Part B

The observations were well presented by most. Many candidates failed to get a positive iodoform test. They were not penalised and gained full credit in all subsequent parts when their analysis followed logically from this observation. The most common error was stating that the solution 'turned green' with the dichromate(VI) test. It was necessary to describe the change fully i.e. 'turned from orange to green' to gain credit. Most candidates attained at least 2 out of 3 marks.

Analysis of Results

(i) Most candidates were comfortable with this calculation and managed to gain both marks, although some rounded to 1 significant figure and lost one mark e.g. for 0.08 mol dm^{-3}.

(ii) This question was less well answered, with candidates making a number of different errors:

- using 25 cm^3 instead of the mean titre from the second titration as the volume of NaOH
- poor calculation of M_r from the concentration of acid in g cm^{-3} and mol dm^{-3}
- giving an acid structure that did not fit the M_r value calculated

Error carried forward (ECF) principles applied and most candidates scored at least 2 marks.

(iii) Inferences from the organic tests were fair but often lacked detail and/or contained careless answers.

For the dichromate(VI) test, some incorrect answers included
- must be an alcohol – insufficient as it had to primary or secondary
- aldehyde or ketone – lost the mark for ketone

Iodoform test − carbonyl bond or secondary alcohol were the most common errors

Silver nitrate test − candidates referred to 'halides' rather than halogens

(iv) Many gave the correct structure but even if they didn't, the second mark could still be attained by ECF. Most scored at least 1 mark.

(v) Most scored 1 mark for the NMR spectrum by linking specific protons to their chemical shifts (or identifying missing signals if their structure did not reflect the NMR provided). Many fewer candidates gained the second mark for the splitting patterns, which was intended to be a discriminator. A good proportion referred to a split signal but did not explain its origin, e.g. "the methyl group at 0.9 ppm is a doublet as expected". It was necessary to mention the presence of one H atom on the adjacent carbon atom for this mark to be awarded.

Practical Methods and Analysis Task

General Comments

This was the second examination of this unit for the GCE specification and 1961 candidates sat the paper.

The paper proved successful in that it differentiated well. Some marks were accessible to almost all candidates whilst others were gained only by the most able. This led to a good distribution of marks with all available marks being scored by the most able candidates. The mean mark was 15.7 out of 30. The best answered question as a whole was question 1, with question 2 being the least successfully answered.

Atebion Cyfrwng Cymraeg

Ychydig yn îs na 7% o'r ymgeiswyr safodd y papur trwy gyfrwng y Gymraeg. Nid oedd llawer o wahaniaeth rhwng safon yr atebion ar y papurau yn y ddwy iaith, gyda'r mwyafrif o atebion anghywir yn dilyn yr un patrwm a'r canolfannau Saesneg. Marc cymedrig ymgeiswyr cyfrwng Cymraeg oedd 14.8. Nid iaith y cwestiynau achosodd anhawster ychwanegol i'r ymgeiswyr − diffyg gwybodaeth a dealltwriaeth oedd y rheswm dros golli marciau.

Question 1

(a) (i) Generally, this question was well answered with most candidates stating that grinding the eggshell increased the rate of reaction / increased the surface area of the calcium carbonate.

(ii) Most candidates could state why the burette was rinsed with the NaOH(aq) before filling up. Stating 'to clean the burette' was insufficient for award of the mark.

(iii) It was clear that most candidates understood why the contents of the conical flask were swirled during the titration. However, stating 'to mix the reactants' was not awarded the mark.

(b) Most candidates identified titration 4 as having the largest percentage error in the volume of NaOH(aq), and then went on to correctly explain in terms of the smallest volume of NaOH(aq) used.

(c) (i)&(ii) Pleasingly, the majority of candidates ordered the six stages of the calculation correctly, then used this scaffolding within the six stages to correctly calculate the percentage by mass of $CaCO_3$ in the eggshell as 93.5% (using the data from titration 3).
Many candidates who did not correctly order the six stages of the calculation wnet on to score 2 out of the 6 available marks for correctly calculating the number of moles of HCl added, and the number of moles of NaOH used. The most common error was failing to calculate the moles of HCl that *reacted*.

(d) Poorly answered on the whole. Very few candidates could correctly explain why Lowri's statement was incorrect. The most common incorrect answer was 'the water that remained would add to the mass of the eggshell and therefore increase the percentage by mass of $CaCO_3$ present'.

(e) Nearly all the candidates completed the table of 'titre volumes' correctly, although a few did not record all the readings to 2 decimal places. Pleasingly, the majority then went on to identify concordant volumes and hence calculate the mean titre as 15.48 cm^3.

(f) This question asked for one advantage for each of the different methods used by Rhodri and Lowri. Whilst a range of mark scheme answers were seen, it was clear that a significant number of candidates could not identify the advantages of both methods.

Question 2

(a) (i) This question clearly differentiated between those that had a thorough understanding of s-block / inorganic chemistry and those that had not. Some excellent answers were seen as these candidates worked logically through each of the five tests. Thus, the most able candidates scored full or nearly full marks.

However, it was surprising to see that a number of A2 candidates were unable to score any marks at all for this question. These candidates were unable to identify the salt as containing a Group 2 cation from the observation (insoluble carbonate) in Test 1. When the correct conclusion was drawn from Test 1, the trend in solubilities of the hydroxides (Test 2) was often not known, leading to an incorrect Group 2 cation being suggested.

Similarly, using the observation from Test 3, some candidates were unable to identify the anion as iodide.

For Test 5, an observation of solution becoming colourless / straw coloured / less coloured was required for award of the mark. No credit was given for ‘solution becoming clear’.

(ii) Only a very small minority of candidates could explain the observation in Test 5 in terms of the reduction of iodine to iodide by the thiosulfate ion. These same candidates were often able to give the equation for the redox reaction taking place.

(b) Candidates were asked to give one further test to confirm the identity of both the cation and the anion in the unknown salt. ECF marks from the incorrect identification of the cation (from Group 2) and the anion in the inorganic salt were credited. Once again, however, this question was very poorly answered.

Question 3

(a) The majority of candidates managed to correctly calculate the number of moles of citric acid and sodium hydrogencarbonate used in the experiment and hence scored 1 of the 2 marks.

However, only a minority of candidates were then able to use the calculated moles and the stoichiometric equation *to show* that the sodium hydrogencarbonate was present in excess.

(b) Poorly answered, with only a minority of candidates scoring all 3 marks.
The most common errors included

- not converting the enthalpy change of +78.8 KJ mol^{-1} into +78800 J mol^{-1}
- using an incorrect mass of 16.0 g or 66.0 g rather than 50 g in the thermochemical expression $\Delta H = -\frac{mc\Delta T}{n}$
- giving the final temperature as a temperature <u>increase</u> on the initial temperature of 24.4°C

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