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# **GCE EXAMINERS' REPORTS**

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**CHEMISTRY**  
**(Including AS Legacy Units)**

**SUMMER 2016**

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<b>Unit</b>	<b>Page</b>
CH1	1
CH2	5
CH3	11
CH4	12
CH5	16
CH6	20

**CHEMISTRY**  
**General Certificate of Education**  
**Summer 2016**  
**Advanced Subsidiary/Advanced**  
**CH1**

**General Comments**

This paper was sat by 586 candidates of whom the vast majority were repeating this unit. The examiners felt that the paper had worked well with nearly all candidates being able to demonstrate their knowledge and understanding of the topics in this first unit, having had experience of other units in this specification.

The most difficult questions to answer were those where an application of a learnt principle was required, particularly where the form of calculations was not as had been set in the past. Some candidates lacked precision in longer responses and lost marks although they clearly knew what the questions required.

This paper had a number of questions that required mathematical skills. In general the examiners felt that most candidates displayed good knowledge of the mole concept. Incorrect and excessive truncation of numbers during calculations continues to be seen and candidates are reminded that truncation should not be used during calculation stages. In general the answer should be given to the same number of significant figures as the data in the question, unless another number is specified.

**Sgriptiau Cyfrwng Cymraeg**

Ar y cyfan, roedd safon yr atebion ar y sgriptiau Cymraeg ychydig yn wanach na'r rhai ar y sgriptiau Saesneg. Mi roedd y mwyafrif o atebion anghywir yn dilyn yr un patrwm â'r papurau Saesneg.

Roedd y termau a ddefnyddiwyd yn gyson iawn ar draws canolfannau ar wahân i'r gair ar gyfer 'shielding' yng nghwestiwn 10(a). Defnyddiwyd y gair 'cysgodi' gan y rhan fwyaf o'r canolfannau ond defnyddiwyd y gair 'tariannu' gan ychydig o ganolfannau. Roedd yr ymgeiswyr yn defnyddio'r termau Cymraeg yn rhugl a hyderus. Roedd yr enghreifftiau lle defnyddiwyd ambell air Saesneg yn brin iawn. Yn y rhan fwyaf o'r atebion i gwestiynau estynedig roedd safon yr iaith Gymraeg yn uchel iawn, er enghraifft, yr atebion i gwestiynau ar y sbectrwm allyriad, cyfradd adwaith ac egnïon ïoneiddiad olynol magnesiwm. Collwyd marciau oherwydd diffyg dealltwriaeth a gwybodaeth ac nid oherwydd yr iaith a ddefnyddiwyd yn y papurau.

## Section A

1. This was an easy first mark for most candidates, although some candidates did not realise that an atom of chromium has its 3d and 4s orbitals singly occupied.
2. Nearly all candidates gained credit for choosing the correct response about ionisation energies.
3. (a) Most candidates gave the symbol of the correct nuclide but some omitted the atomic number that was required as part of the answer.  
(b) This half-life calculation required candidates to work back to the start of the decay rather than calculate the mass of the product after several half-lives. A number failed to do this and many incorrect answers were seen.
4. There were two marks for this question – for identifying the relative isotopic masses of the two bromine isotopes and the proportion of these present in bromine trifluoride. Some candidates did not mention the percentage abundances.
5. It was surprising how many candidates failed to gain this mark. Common errors included showing a lower ‘hump’ for  $T_2$  but underneath the ‘hump’ for  $T_1$  rather than to its right.
6. (a) Nearly all candidates knew the values of temperature and pressure for a standard state.  
(b) This was a straightforward calculation but some candidates did not get the correct answer of  $-100$  kJ.

## Section B

7. (a) Many candidates continue to find questions about empirical formulae difficult to answer. A number of candidates gave  $C_2H_4N_4O_4$ .  
(b) (i) This was the best answered calculation on the paper but some candidates gave alternative values based on the wrong expression from the energy cycle.  
(ii) There were some sloppy answers to this question where candidates indicated the activation energy by using an arrow that fell short of the correct height. Some candidates did not realise that an explosion must be exothermic and gave an endothermic reaction profile!  
(iii) This question was well answered.  
(c) (i) This was well answered.  
(ii) The vast majority of candidates gave a creditworthy answer here.  
(d) (i) The relationship between energy, frequency and wavelength was well understood and correct responses were generally given.  
(ii) A number of candidates referred in their answers to the hydrogen spectrum and wrote about the Balmer series and  $n = 2$ . A few candidates confused absorption and emission.

8. (a) (i) Most candidates correctly described the meaning of a 'base'.
- (ii) The commonest correct answers were 'water left in the burette after rinsing' or 'overshooting the end point'.
- (iii) There were many good answers to this calculation.
- (iv) A number of candidates did not realise that using a smaller volume of sodium hydroxide solution could lead to increased errors.
- (b) (i) Although a few candidates plotted the two figures incorrectly this was generally well done.
- (ii) Quite a few candidates missed the  $10^{-4}$  on the x-axis and lost a calculation mark. Some did not give their answer to the required 3 significant figures. A few candidates rounded up during their calculation and then gave their answer to three significant figures.
- (c) It was surprising to see how many candidates could not balance this equation, gave carbon itself as one of the products or thought that the formula for nitrogen gas was just N.
- (d) Most candidates had a good knowledge of catalysts.
9. (a) (i) Although the correct answer of  $-90 \text{ kJ mol}^{-1}$  was commonly seen, there were still some candidates who did not know the correct expression and obtained a wrong answer; often  $+90$  or  $-831 \text{ kJ mol}^{-1}$ . Some candidates used the enthalpy value for a C—O bond when they should have used the value for carbon monoxide.
- (ii) Surprisingly, this was often poorly answered with candidates stating that the difference between the values was due to heat lost to the surroundings.
- (iii) This too was often poorly answered. Some candidates did not recognise that the difference between the two equations was the physical state of methanol. Heat is given out when a gas condenses to a liquid and therefore the equation producing liquid methanol would be more exothermic.
- (iv) The use of the term 'dynamic equilibrium' and the application of le Chatelier's principle in the production of methanol were understood by most candidates.
- (b) (i) Many candidates found the 653 kJ difference but failed to relate this to the correct reduction in the number of carbon atoms in the alcohols.
- (ii) An easy two marks for nearly all candidates.
- (iii) This calculation was often poorly done and once again demonstrated that if the question requires application rather than the recall and use of a familiar equation, problems are encountered.

10. (a) The examiners read many good answers but a number of candidates failed to mention the important factors. Some wrote that 'nuclear charge increases' rather than 'effective nuclear charge increases'. Some responses were seen where 'more shielding' was used inappropriately for the removal of electrons from the same subshell. Some candidates considered that electron pair repulsion was an important factor that needed consideration.
- (b) (i) Many candidates gave the correct answer of 90 for the  $A_r$  of strontium in this sample.
- (ii) Numbers often appeared to be scattered randomly over the page in this calculation. The clear setting out of calculations is to be encouraged as this enables examiners to award marks for intermediate steps even when these lead to an incorrect answer.
- (iii) There were a number of correct approaches to the answering of this question but few candidates gained all three marks.
- (c) Many candidates realised that this question required the application of le Chatelier's principle but a good proportion of responses lacked the precision required for credit to be awarded.
11. (a) This was very poorly answered. A number of candidates thought the cotton wool was to keep the carbon dioxide in the flask when the whole point of the experiment was to monitor the loss in mass due to carbon dioxide being lost from the flask!
- (b) (i) The expected answer was not always provided.
- (ii) Although many candidates gave an acceptable answer for the initial rate of the reaction, fewer were able to give the appropriate unit.
- (iii) This was poorly answered. Although the question clearly indicated how the marks could be obtained, a number of candidates chose to ignore this. References to the decreasing concentration of HCl /hydrogen ions and the reducing surface area of magnesium carbonate were not often clearly differentiated and many just wrote 'fewer reactants'. A few candidates wrote about the 'concentration' of the magnesite.
- (c) Although the question asked for actual pH values these were sometimes missing.

**CHEMISTRY**  
**General Certificate of Education**  
**Summer 2016**  
**Advanced Subsidiary/Advanced**  
**CH2**

**General Comments**

With the introduction of a new GCE AS course, this CH2 was set as a paper set solely to enable candidates to complete the outgoing specification. The paper attracted a much smaller entry than previous years, almost all of whom were repeating the unit. Almost all were second year A level students who were also entering CH4 and CH5 in the same series. It might be expected that the content studied for CH4 and CH5 might be reflected in improved marks in CH2, especially in areas such as organic chemistry and periodicity.

A wide range of marks seen however relatively few candidates attained the highest marks, with the number gaining marks above 70 being lower than in previous years. This may reflect the different nature of the cohort. The number gaining full marks in Section A was significantly lower than previously seen, with only a minority of candidates attaining 2 marks on question 4 and question 7. In Section B, many candidates found question 12 challenging and it was disappointing to see that only a minority of candidates gained full marks on straight recall topics such as the bonding and structure of ethene, the mechanism of electrophilic addition and electrical conduction in metals and ionic compounds.

Calculations showed a mixed response. Where the questions were expressed in an identical manner to many past papers, such as the calculation of empirical formulae, the answers were of a high standard. Where candidates were faced with applying familiar skills but in a slightly different context, such as in question 7, or combining these skills, such as in question 9(c)(iii), the work was of a much lower standard. This perhaps reflects some candidates who learn calculation methods by rote without understanding the processes.

**Sgriptiau Cyfrwng Cymraeg**

Nifer bach o bapurau cyfrwng Cymraeg oedd eleni ond gwelwyd safon iaith da iawn yn y mwyaf. Roedd llawer yn ennill y marciau am ansawdd eu cyfathrebu ysgrifenedig. Roedd iaith rhai ymgeiswyr yn rhy amhendiant, ond roedd cynifer o ymgeiswyr cyfrwng Cymraeg a chyfrwng Saesneg yn dangos y broblem hon. Rhaid sicrhau fod atebion yn hollol sbesiffig ac yn osgoi'r defnydd o 'e' a 'hi' lle nad yw'n glir at beth y maent yn cyfeirio. Roedd hwn yn broblem sylweddol yn y cwestiynau ar fondio a phriodweddau.

## Section A

1. Almost all candidates gained this mark, although a small number were penalised for stating a precipitate was formed without giving its colour.
2. The majority gained this mark. A few gave the structure of 1,2-dichloropropene, and others 2,3-dichloropropane. It was disappointing to see some candidates drawing carbon atoms with five bonds in their structures.
3.
  - (a) Most gained this mark but some did not answer in sufficient detail, not stating for example how many electrons are shared or from where they come.
  - (b) Although many gave acceptable answers here, there were a large range of incorrect answers. Some candidates simply stated the meaning of ionic and covalent bonds, whilst others compared the electronegativity values of oxygen and chlorine without reference to the differences between these and aluminium.
4.
  - (a) Few candidates gained this mark. A large number gave the order 'sodium, magnesium, aluminium, silicon, chlorine' without recalling the decrease in ionisation energy between magnesium and aluminium. Almost every possible order was seen.
  - (b) This was answered very poorly. A wide range of incorrect answers were seen. A common incorrect answer was 'chlorine, silicon, sodium, magnesium, aluminium' with no appreciation of the extremely high melting temperature of silicon. A few candidates thought that the gas chlorine had the highest melting temperature!
5. Almost all candidates gained this mark, with many of the few who failed to do so making careless errors such as giving the products as  $C_2H_4$  and  $C_8H_{16}$ .
6. Almost all candidates gained this mark, with a few penalised for failing to include acid.
7. This question proved challenging for many candidates and it was not uncommon for it to be left unanswered. A number of candidates attempted to use all the numbers without any understanding of their meaning or how to combine them. Some gained one mark for finding the difference in solubility at the two temperatures.

## Section B

8.
  - (a) This was well answered with the hydrogen bonding between molecules of ethanol and water being described clearly.
  - (b) Many candidates gained two marks here but a few gave the conditions for dehydration of ethanol to form ethene, rather than hydration of ethane to give ethanol.
  - (c)
    - (i) Most gained this mark although a few gave an answer based on the O—H absorption which shows that a reaction had occurred rather than showing that *all* the chloroethane had been converted.

- (ii) I Most were able to answer this question. The most common incorrect answer was to discuss heterolytic bond fission with the formation of ions.
- II This was generally well answered but some gave an unbalanced equation or placed a 2 in front of the chlorine radical in an attempt to balance an incorrect equation.
- III Fractional distillation was familiar to most candidates.
- (iii) I This was generally well answered. No credit was given for 'NaOH(aq) in alcohol' with the presence of (aq) negating the mark for alcohol or anhydrous solvent.
- II A wide range of answers was seen here, including a number of terms preceding 'elimination'.
- III Many answers seen here were disappointing. The question asks for the structure and bonding in an ethene molecule, but many candidates did not refer to structure at all, or appreciate the difference between structure and bonding. The answers on bonding varied in standard, with many GCSE-style answers referring to a molecule with a C=C double covalent bond and single bonds from the carbons to a total of four hydrogens. Although these gained one mark, a full answer required a more detailed discussion of the double bond with reference to  $\sigma$  and  $\pi$  bonds. Some candidates simply stated that  $\pi$  bonds were formed by overlap of p orbitals without indicating that these overlap sideways or showing this in a diagram. In a number of answers candidates showed a clear misunderstanding with the idea that  $\sigma$  bonds are formed from s orbitals and  $\pi$  bonds from p orbitals. Many candidates gained marks for clear, labelled diagrams, however some produced diagrams that showed a double bond and an additional  $\pi$  bond, which did not gain credit.
9. (a) (i) This was generally well done. Candidates who did not gain marks here had often drawn the ammonia molecule or drawn ammonium without a coordinate bond.
- (ii) Most were able to recall this value.
- (iii) Many gained three marks here, although a small number were unaware of the lone pair and suggested a trigonal planar molecule. This was particularly disappointing for a molecule that is generally given as the archetype of the pyramidal shape.
- (b) Most were able to identify the reduction of oxygen from 0 to  $-2$  but the oxidation states of nitrogen were more challenging. It was disappointing to see some suggesting hydrogen was oxidised or reduced with oxidation states such as  $+3$  quoted for an element that has only one electron when a neutral atom!

- (c) (i) Almost all gained this mark.
- (ii) Most were able to balance this equation.
- (iii) This proved very challenging for many candidates. Many started by attempting to calculate the number of moles of calcium carbonate or calcium phosphate in 1.202 g and this then led to a range of incorrect calculations. Most candidates quoted their answers to three significant figures as required.
10. (a) (i) This was generally well answered with most realising that the similar hydrogen bonding between the molecules in each case was not the important factor. A few stated that the 'intermolecular forces' were greater in hexanoic acid, without stating which *type* of force was greater. This was not credited.
- (ii) Many gained marks in this question, although the number gaining full marks was fewer than in part (i). Most gained the mark for identifying propanoic acid as the more soluble and stating that the solubility is due to the ability to hydrogen bond with water molecules. The comparison with hexanoic acid was expressed much more poorly and statements such as 'hexanoic acid is more hydrophobic' did not gain the final mark.
- (b) (i) There were many disappointing answers to this question. Many did not give skeletal structures, or included 'C<sub>2</sub>H<sub>5</sub>' in the structures shown. Others did not show the molecule requested with pent-3-enoic acid being common. When the correct molecule was shown, many could not show the correct isomers and it was not uncommon to see the same isomer shown for both *E* and *Z*.
- (ii) There were several possible answers to this question, so it was especially disappointing to see so many incorrect ones. Some candidates drew saturated molecules and gained no marks.
- (c) (i) Most were familiar with this test. A very few still gave 'clear' as a colour.
- (ii) I Almost all gave the correct formula here. A very few left out the hydrogen completely and gave a formula of C<sub>10</sub>Br<sub>4</sub>O which gained part credit only.
- II Only the very best candidates realised that the molecular formula must be twice the empirical formula to give two oxygen atoms and hence indicated that 4 double bonds were present which added 4 bromine molecules in the chemical test.
- (iii) This was generally well answered. A few gave a generally correct mechanism but to give the incorrect isomer, and this was given partial credit. A few candidates failed to make a reasonable attempt at this mechanism and gained no marks.

11. (a) (i) This question was not intended to assess candidates drawing ability, however the diagrams required a clearly cubic 3D representation. Some candidates made no attempt at 3D and were penalised for this. The labelling of ions gained marks in most cases but no credit was given for neutral Cs and Cl atoms.
- (ii) Many gained this mark, although those that referred to the size of caesium or sodium *atoms* did not.
- (b) This was generally well answered with the different intermolecular forces in each clearly identified. A few candidates did not refer to the forces being *intermolecular* so did not gain this mark. Some others focused on the differing ionisation energy or electronegativity of F and Cl and gained no marks.
- (c) Most could explain the reasons for the conductivity of sodium however some omitted the conditions under which it conducts. The answers on sodium chloride were poorer. Many referred to the need to melt or dissolve the compound but answers stating that this allowed *electrons* to move were common and did not gain marks.
- (d) (i) Most gained this mark. Current and past uses were credited. It was disappointing to see some answers that showed a lack of understanding. Some candidates stated 'in deodorants' which was not given credit.
- (ii) Most candidates gained some marks here, although some did not refer to the information provided in the table. Poorer answers included vague statements such as 'the bonds in chlorobromocarbons are weaker' without reference to which bonds or what they are weaker than. Better answers were able to clearly identify the decomposition route of ozone caused by chlorine radicals and how these are formed. These candidates also tended to identify and explain the lack of reactivity of hydrofluorocarbons. It was generally only the best candidates that linked the weaker C—Br bond to the inability of the chlorobromocarbons to reach the ozone layer.
12. Candidates found this question challenging and it clearly distinguished candidates aiming for the highest grades. Very few candidates gained all 10 marks here however almost all gained some marks.
- (a) (i) Many answers referred to the removal of water however only those that realised that heating to constant mass indicated the removal of ALL water gained the mark. A number referred to removal of impurities and gained no marks.
- (ii) This was a standard calculation of water of hydration and was answered correctly by many candidates.
- (b) Many candidates correctly identified the number of moles of acid used and gained 1 mark but many fewer were able to use this to calculate the value of c.

- (c) Most identified the ion E as chloride from the colour of the precipitate, however weaker candidates gave a range of answers which were incorrect. Some did not show an appreciation of the difference between a chlorine atom and a chloride ion. The number of ions present was poorly answered.
- (d) Candidates were required to combine their answers to previous parts of the question to answer this part. There were a range of possible answers following from errors carried forward, however the metal ion identified had to be a p-block metal and so any answers giving d-block metals, s-block metals or p-block non-metals were not accepted.

**CHEMISTRY**  
**General Certificate of Education**  
**Summer 2016**  
**Advanced Subsidiary/Advanced**  
**CH3**

**General Comments**

This is the final report on the CH3 unit after over a decade of existence during which more than twenty thousand students have undergone and hopefully enjoyed their practical assessments.

Over two hundred candidates submitted the two practical exercises and the marks awarded were generally very high.

This report will focus on the way in which these experiments relate to the practical and mathematical requirements of the new specification.

**Thermochemistry 3.1A-D**

The important skills here are weighing, careful measurement and graphical analysis. Weighing errors cannot be corrected, the mass transferred must be within the allowed range and accurately recorded to the full number of significant figures offered by the balance. Graphs must be clearly titled, axes labelled and use as large a scale as possible to maximise sensitivity. Extrapolation back to the point of mixing requires some judgement and it is easy to make an error in measuring  $\Delta T$ . General techniques such as stirring and adequate insulation come into play. Mathematically, care is needed in scaling up to molar amounts, watching the signs, since most  $\Delta H$  values are exothermic and stating the final result to a sensible number of significant figures, probably about three for an experiment with around 5% error in measurements. To write down the complete calculator output is absurd and shows a lack of understanding of the whole process. On the other hand over-truncation of a result, such as returning a value of 0.94 as 0.9, destroys data of significance produced by the experiment.

**Kinetics 3.2A and B**

These two interesting experiments usually give very satisfactory results and are encouraging for students' confidence. Choosing and making up mixtures and timing the runs causes little difficulty. The general points about graphs are dealt with above; however certainty and precision in the results is increased if the concentration ranges used are maximised. As in all kinetic work temperature is the main variable and with an increase in rate of around 6% per degree more precise rates are unlikely to be achieved in un-thermostatted conditions. So far as the plots are concerned good straight lines are obtained for the peroxide in 3.2A and the thiosulfate in 3.2B but the dependence on acid concentration in 3.2B may legitimately show a curve, depending upon the actual concentrations chosen.

**Acid-base Titrations 3.3A-C**

Here the skilful manipulation of burettes, volumetric flasks and pipettes and a reliable and careful titration method are the key to consistent and good results. It is here that one sees the greatest range of skill in candidates' ability to control the burette tap and judge the approach of the endpoint. Adequate practice is essential. Mathematically, judgement is needed as to which burette readings are acceptable, to calculate a mean value and to estimate its uncertainty.

**CHEMISTRY**  
**General Certificate of Education**  
**Summer 2016**  
**Advanced**  
**CH4**

**General Comments**

The paper proved accessible with able candidates scoring high marks and weaker candidates being able to match some of the marking points. Almost all candidates attempted all parts of the paper so that there was no evidence that shortage of time was a significant factor affecting performance.

In previous papers it has been noted that a significant number of candidates seemed unfamiliar with some practical techniques. It was therefore pleasing to note that there was evidence that many candidates understood the significance of these suggesting that they had had the opportunity to carry out relevant practical exercises.

Marks however continued to be lost when candidates did not read the question carefully. This led to answers that used many of the words relevant to the topic but did not actually address the specific question set.

**Section A**

1. (a) (i) Nearly all candidates recognised the type of reaction involved.
- (ii) Most candidates realised that the negative Tollens' test showed the absence of an aldehyde. A few stated that it showed that a ketone was present – clearly this cannot be concluded from the test as described.
- (iii) An acceptable name for the type of reaction and at least some of the isomers were given by most candidates. A number however drew, quite correctly, two straight-chain isomers but then the third as having a branched chain.
- (iv) It was evident that most candidates were familiar with skeletal formulae.
- (b) (i) Many candidates identified the diazonium compound but, to gain credit, the positive charge had to be shown on the correct nitrogen atom.
- (ii) Reactions with both functional groups were possible. Many candidates gave either the ester or the amide.
- (iii) Apart from a few responses that showed no understanding of the formation of peptides, this was generally well done. Candidates coped well with the comparatively complex nature of the amino acids involved.

2. In general, candidates who had carried out relevant practical work would have been better equipped to answer parts (a) and (b) than those who hadn't. It was apparent that many had such experience. However, a significant number of candidates lost marks for imprecise answers that did not actually address the points asked for in the question.
- (a) Most recognised that this was concerned with the triiodomethane reaction and realised that ethanol and propanone could not be distinguished by its use. A number however did not state the specific group present that is responsible for the positive test in each of these compounds.
  - (b) The lack of reaction with phenols, compared with carboxylic acids, was generally stated. For full marks it was necessary to state the nature of the bubbles and also to explain the difference in acidity between these functional groups.
  - (c) This was the least well answered part of this question. Many candidates did not identify the nature of the error in the statement or make it clear that it is the strength of the intermolecular forces that affects melting temperatures.
3. (a) Apart from a few candidates, who stated that it was the **molecular** formula of the stereoisomers that must be the same, most were able to describe stereoisomerism.
- (b) This is an example where a number of candidates lost marks through not reading the question. This states that a 'chemical method' must be used. Spectroscopic methods were not credited.
  - (c) (i) To be awarded both marks it was necessary to include the use of plane polarised light and also that the sign shows that the isomers rotate the light in opposite directions. Many candidates matched both points.
  - (ii) Many candidates used the numbers to show the origin of  $-39.2^\circ$ . Fewer realised that this value would be obtained because equal amounts of glucose and fructose would be present.
  - (d) Nearly all candidates correctly identified the chiral centre.
  - (e) Although a few 2-dimensional diagrams were seen, most candidates recognised that a 3-dimensional one is needed to show chiral centres. A few used the thalidomide molecule but most chose, as suggested in the question, a simple molecule with a carbon atom attached to four different groups.
  - (f) Only the most able candidates recognised that the reaction described was hydrolysis and that the ring would break at the amide group.
  - (g) (i) Most candidates drew correct structures with a few omitting the O in one of them.
  - (ii) Most realised that hydrogen bonds are involved in consideration of solubility. For full credit it was necessary to state that the sugars contain many OH groups and also that the hydrogen bonds are between the sugar and water.

## Section B

4. This question gave candidates the opportunity to show their knowledge of a variety of spectroscopic techniques and all candidates were clearly familiar with at least some of them.
- (a) This is another example of a question where a considerable number of candidates wrote correct information but did not address the question set. The question in fact asked how the peaks are formed and this meant that consideration of the relevant energy changes was required.
- (b) (i) Most candidates correctly calculated the  $R_f$  value.
- (ii) I Only a small number of correct answers were seen. A wide variety of unacceptable answers were given.
- II Most candidates understood the principles involved and thus were able to calculate the percentage. It was pleasing to note that most did show the method used.
- (iii) Since the question asked about the different information that could be obtained from thin layer chromatography (TLC) compared with gas chromatography (GC) it was expected that candidates would discuss the fact that TLC shows the number of components in a mixture whilst GC allows the amount of each component to be determined.
- (c) (i) It was expected that the mass spectrum would allow candidates to deduce the  $M_r$  of the compound and then use the percentage of carbon to find the number of carbons present in each molecule. This approach was adopted by many but a significant number unsuccessfully tried to use the 66.7% of carbon, and the fact that this meant that there was 33.3% of oxygen and hydrogen, to calculate an empirical formula. Whichever approach was taken many candidates gave a correct molecular formula.
- (ii) In the interpretation of  $^1\text{H}$  NMR spectra candidates are advised to state the number of hydrogen environments, to use the numbers given to determine the number of hydrogens in each environment, to look at the significance of the splitting patterns and to link at least some of the  $\delta$  values to the groups present. Few candidates considered all these aspects – the least common being actually stating that there were three distinct hydrogen environments.
- (iii) A number of candidates gave a correct structural formula – some obtaining this even if their evidence was incomplete.
5. (a) Nearly all candidates gained some marks in this part. As noted in previous reports, when using curly arrows as part of a mechanism, candidates must be careful to show exactly the origin and destination of the arrow. In the intermediate cation in this particular mechanism the gap in the  $\pi$  bond system must correspond to the position of substitution on the ring.

- (b) This part was focussed on practical procedures and it was pleasing to note that many answers showed good understanding of at least some of these.
- (i) At A level a precise answer is needed. This means that evaporation and condensation must both be named or described. Some idea of how this is achieved or the significance of limiting loss of reagents/ products was also required.
  - (ii) Very few correct equations were given. Many were unbalanced when water was omitted as a product.
  - (iii) It was evident that many candidates had carried out a similar preparation.
  - (iv) In previous sessions it has been noted that candidates seemed confused about the reasons for the different stages in recrystallisation. This year this question was **much** better answered.
  - (v) Most candidates used melting temperatures in some way but it was necessary to state how they are used. A few suggested using boiling temperature but, as benzoic acid is a solid at room temperature, this was not accepted.
  - (vi) The majority of candidates were obviously familiar with the method involved in this calculation. A number however failed to use one or both of the relevant  $M_r$  values.
  - (vii) A variety of answers were accepted but these had to be concerned with this particular preparation. Vague statements such as 'not all benzene reacts' or 'some product is lost' were therefore not considered worthy of credit.

# CHEMISTRY

## General Certificate of Education

Summer 2016

Advanced

CH5

### General Comments

Around 1900 candidates sat the paper and the mean mark was 44.1. There was a good spread of marks, with the highest being 78 out of 80. It was pleasing to see that this CH5 paper was accessible to the vast majority but still included questions that challenged the most able. Many excellent scripts and only a few very poor ones were seen. Section A was answered less well than Section B, which has been a common feature of recent CH5 papers.

The calculations proved to be a mixed bag with many well done e.g. questions on redox titration, free energy and the Born-Haber cycle, while others which required some degree of manipulation caused major problems e.g. questions on pH,  $K_w$  and equilibrium constants. In many cases the calculation questions were answered to a higher standard than the recall questions.

The quality of written communication was good on the whole but there were numerous examples where candidates' responses lacked clarity. Failing to read questions carefully was another common weakness. This often resulted in candidates not gaining credit when they appeared to have good knowledge of the topic area. It was also pleasing to note that good knowledge of orders of reaction, choice of indicators and transition metal chemistry was shown by a significant number of candidates. Skills writing equations and simple chemical formulae again proved to be disappointing in many cases.

### Sgriptiau Cyfrwng Cymraeg

Braf yw cael nodi fod safon ieithyddol yr atebion a gyflwynwyd yn gyfoethog ac yn addas. Gwelwyd enghreifftiau o ysgrifennu graenus a phwrpasol o bob un o'r canolfannau.

Er y darlun cadarnhaol hwn roedd rhai gwahaniaethau rhwng y sgriptiau cyfrwng Cymraeg a'r sgriptiau cyfrwng Saesneg yn dod i'r amlwg. Cafwyd enghraifft yng nghwestiwn 2(a). Roedd nifer o'r ymgeiswyr cyfrwng Cymraeg yn defnyddio'r termau 'dadelfennu' neu 'hollti' yn hytrach na 'daduno'. Yna, yng nghwestiwn 2(b)(iii), roedd nifer yn cyfeirio at y 'diweddbwynt' yn hytrach na'r 'pwynt cywerthedd'. Y ddau fater arall a ddaeth i'r amlwg oedd amharodrwydd yr ymgeiswyr cyfrwng Cymraeg i ddefnyddio'r cysyniad o 'hollti'r orbitalau 3d' wrth ateb cwestiwn 4(b)(ii) a'u bod yn defnyddio'r term 'pont halen' yn hytrach na 'phont halwyn' yng nghwestiwn 4(ch)(i).

Ar y llaw arall, atebodd yr ymgeiswyr cyfrwng Cymraeg gwestiwn 4(b) a chwestiwn 5(c) yn ddeheuig gan ddangos cryn ddealltwriaeth. Anodd fyddai cynnig eglurhad dros y man-wahaniaethau hyn rhwng atebion ymgeiswyr yn y ddwy iaith. I gloi, roedd hwn yn bapur a atebwyd yn hynod o dderbyniol gan yr ymgeiswyr cyfrwng Cymraeg, a phob clod iddynt am eu hymdrechion.

## Section A

1. This was easily the best answered question in Section A.
  - (a)
    - (i) Fairly well answered. A significant number scored both marks, however too many candidates did not use the graph and so lost the marks.
    - (ii) Part I was very well answered with around four candidates in five correctly determining the orders and gaining both marks. Part II was poorly answered. Over half omitted  $[\text{CH}_3\text{COCH}_3]$  and gave an incorrect rate equation. However, the vast majority gained the marks for calculating the value of the rate constant in part III following the error carried forward principle.
  - (b) Although over four candidates in five knew what the term 'rate-determining step' meant in part (i), only about one-third could suggest suitable equations for the reaction in part (ii).
2.
  - (a) While the vast majority were able to give a good description of a weak acid only a small percentage could adequately explain the meaning of a *dilute* acid. Most answers referred to a low concentration of  $\text{H}^+$  with no reference to comparative volumes of acid and water.
  - (b)
    - (i) Curve **A** was correctly identified by the vast majority and about half the candidates could give a reason to justify the answer.
    - (ii) About two-thirds correctly chose letter **Y** as the acid used to give curve **B**. A significant number gained a further mark by giving a correct calculation to support their answer, but only a small percentage gained full marks by using the shape of the curve to further support their choice.
    - (iii) Very well answered. The correct indicator and the reason for using it were given by the vast majority.
    - (iv) Surprisingly only fairly well answered. About a third of candidates failed to realise that the volume of NaOH at the equivalence point was  $30\text{ cm}^3$ .
  - (c) This proved to be the most difficult part-question on the whole paper. Only a small percentage mentioned salt hydrolysis while most were content to state that the salt was formed from a strong acid and weak base. Some tried to explain in terms of the lone pair of electrons on the nitrogen and electronegativity.
3.
  - (a) Generally well answered with around two-thirds gaining the mark. The vast majority knew the expression for  $K_w$ , however a significant number gave an incorrect unit.
  - (b) Generally poorly answered. Most candidates failed to show understanding of the concept that a solution is neutral when  $[\text{H}^+] = [\text{OH}^-]$  not when  $\text{pH} = 7$ . About half failed to score a mark. A significant number managed to score two marks by calculating  $[\text{H}^+]$  and  $[\text{OH}^-]$  but only a small percentage gained the third mark by showing the significance of the relative concentrations.

- (c) Most candidates chose to draw a diagram and were able to indicate the features required to gain the marks. However, the quality of many diagrams was appalling and would have failed to gain credit if the question had specifically asked for a diagram.
- (d) (i) Only about half the candidates gained both marks on this simple calculation. Many failed to multiply the  $\Delta H_f$  of water by 2 and others were happy to give an answer of  $+891 \text{ kJ mol}^{-1}$ , although anyone with central heating knows that the combustion of methane clearly is not endothermic!
- (ii) Poorly answered. The vast majority did not know what was meant by 'per unit mass'. Only about a fifth gained both marks. A significant minority who realised how to answer did not identify hydrogen as a diatomic molecule and so lost a mark.
- (e) This part was about the principles underlying the operation of a hydrogen fuel cell. Many candidates did not read the question carefully enough and wrote mainly about the advantages and disadvantages of the combustion of hydrogen. A significant number gave correct half-equations or described the reactions taking place at the electrodes. Only a small percentage scored full marks by including reference to the generation of electrical energy via a current or potential difference.
- (f) (i) Well answered. About three-quarters of candidates gave a correct expression for  $K_p$ . Only a few square brackets were seen.
- (ii) This was meant to be a challenging calculation and so it proved. However, over a quarter of candidates gained at least 2 marks out of the 3 and around a third scored 1 mark for the correct unit. Surprisingly, some who calculated the value correctly gave the wrong unit.

## Section B

4. (a) In part (i) only about half the candidates gave the correct answer. Many referred to incomplete d subshells. Part (ii) was better answered. Marks tended to be lost for omitting the '3' in '3d subshell' or thinking that d-orbital splitting does not occur with a  $3d^{10}$  configuration.
- (b) This part required candidates to write about the ligand substitution and precipitation reactions of copper compounds. Although only a minority gained full marks, around two in five candidates scored at least 5 marks out of 7 and about two-thirds scored at least 3 marks. Formulae and colour of the ligands were well known. Marks were lost for omitting 'concentrated' for hydrochloric acid or 'excess' for ammonia. Precipitation reactions proved to be harder to recall and copper hydroxide was often described as a white precipitate.
- (c) In part (i), around two-thirds of candidates knew that starch was a suitable indicator. The calculation in part (ii) was well done with around two-thirds gaining at least 3 marks out of 4. Most candidates used three significant figures and the main error was failing to multiply by four to link the volumes of pipette and volumetric flask.

- (d) (i) Very well answered. Almost all correctly identified the salt bridge but only just over a quarter gave a detailed enough description of its purpose. Many omitted 'to complete the circuit' or referred to movement of electrons rather than of ions.
- (ii) The most poorly answered part of (d). Of the candidates who correctly said 'copper electrode' too many stated 'higher electrode potential' instead of 'more positive electrode potential'.
- (iii) Well answered. About three quarters correctly calculated the emf of the cell.
- (iv) Fairly well answered. Most of the candidates who gave a correct answer also calculated the emf.
5. (a) (i) The vast majority knew that oxidation state II becomes more stable down the group and most could give a reason for this.
- (ii) This part required candidates to show how characteristics of the Group IV compounds change from carbon to lead. Only a minority gained all 7 marks and only just over a quarter scored at least 5 marks. Around three in ten failed to score more than 1 mark. While the acidic and amphoteric properties of  $\text{CO}_2$  and  $\text{PbO}$  were well known, supporting equations were often incorrect. Many also failed to write an equation showing the redox properties of  $\text{CO}$ , despite its use as a reducing agent appearing in the GCSE specification.
- (b) (i) Well answered. Candidates knew why there was an increase in entropy.
- (ii) Again well answered. Around three quarters correctly calculated the entropy change for the reaction.
- (iii) Over half the candidates gained all 3 marks for this free energy change calculation. The two commonest errors were failing to convert joules into kilojoules or vice versa and failing to convert temperature to kelvins.
- (c) This Born-Haber calculation was well answered with around two-thirds gaining at least 3 marks out of 4. The main error was not multiplying the values of the atomisation of chlorine and the electron affinity of chlorine by two.
- (d) The vast majority knew that the chloride ion forms when chlorine reacts with warm sodium hydroxide and most knew that the chlorate(V) ion also forms. However, many lost a mark by also including the chlorate(I) ion.

**CH6**  
**General Certificate of Education**  
**Summer 2016**  
**Advanced**  
**CH6**

### **General Comments**

This is the last full entry year for the operation of the practical CH6 unit although it will be available for one last time in 2017. Performance on this unit was of a very high standard as usual.

This report will focus on areas where marks are often unnecessarily lost and how the CH6 exercises may be useful in the teaching of learners following the new specification in future years.

### **Significant figures**

Marks are still being lost in otherwise good work through incorrect use of significant figures, especially in over-truncation. All results should be expressed according to the precision of the measuring equipment used (e.g., burette readings to 0.05 cm<sup>3</sup>). More figures may be used during any calculation but the final result must reflect this precision. At this level it is only necessary to identify the precision of the main source of error; this will not usually be in a weighing. It is worth noting here that there must be no mistakes in recording the mass used since there is no way of subsequently checking this.

### **Questions on understanding of the experiments**

These are sometimes relatively weakly answered and care and thought must be applied. These questions are “open book” so that there is no excuse for incorrect responses.

### **Preparation tasks**

Three points arise here. The product must be as dry as possible and the drying process not rushed. Poor yields usually result from recrystallisation, rather than the preparation stage, where skill is required to remove impurities using as little solvent as possible while leaving the minimum amount of product in solution. Finally in calculating the yield, the different molar masses of reactant and product must not be forgotten.

### **Identification tasks**

Candidates are provided with a selection of known organic or inorganic compounds and asked to determine which is which by qualitative analysis. A plan is devised after researching their chemistries and implemented. The results are analysed and inferences drawn to enable the compounds to be identified. It is essential that the inferences derived from the observations of the tests are clearly stated to link to the identities of the unknowns. Omission of the 'inference' stage leads to loss of marks even if the results are correct.

## Titration types

Candidates have usually gained sufficient experience of acid-base titrations at AS. Other types will be encountered at A level such as redox titrations using manganate(VII) and iodometric titrations in which iodine is liberated by iodate or copper(II) and titrated by thiosulfate. Although different in detail the basic titration skills of careful mixing and controlled approach to the endpoint are as relevant as ever.

## Temperature effects

These come into play in several types of experiment, most obviously in rate measurements where typically a change of one degree leads to a 6% change in rate. It is not usually practicable for all candidates to work under thermostatted conditions but they should ensure that all their own runs are internally consistent in temperature and thus comparable.

Titration involving the manganate(VII) oxidation of ethanedioates need a temperature of 70°C that requires a careful control. Any experiment to determine solubility will be very temperature-dependent.

Another important area is in the recrystallisation of organic preparations in which cooling substantially reduces solubility and thus increases yield. In the preparation of benzenecarboxylic acid for example the solubility decreases from 5.8 g/100cm<sup>3</sup> of water at 90°C to 0.2g/100cm<sup>3</sup> of water at 15°C and further still if cooled below 5 °C. Control of temperature is also critical in diazo coupling experiments with aromatic amines when the temperature should be held at around 5°C to prevent decomposition of the diazo intermediate.



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