GCE EXAMINERS' REPORTS

GCE (NEW)
CHEMISTRY
AS/Advanced

SUMMER 2017

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WJEC
GCE CHEMISTRY (NEW)

Summer 2017

UNIT 1 – THE LANGUAGE OF CHEMISTRY, STRUCTURE OF MATTER AND SIMPLE REACTIONS

General Comments

This was the second Unit 1 paper for the new GCE specification. Around 3900 candidates sat the paper of which around 900 were repeating the unit. 270 sat through the medium of Welsh. Once again the paper included questions on analysing, interpreting and evaluating scientific information where candidates were asked to suggest the best course of action in new situations and the mathematical questions had less scaffolding and so were more demanding than was the case with the previous specification. The examiners felt that the paper, although challenging, was accessible and offered an opportunity for all candidates to show positive achievement.

Consequently, the examiners were disappointed with the standard of many scripts. As noted in last year's report more marks are lost in basic recall than in dealing with data given in new situations. Candidates are once again advised to read the questions carefully, so that they answer what is actually required.

The mean mark was 31.4, the highest mark 76 and the lowest 1. In Section B the most successfully answered question as a whole was Q6 and the least successfully answered was Q9. The easiest parts on the entire paper proved to be Q5, Q8*(c)*(i) and Q4*(b)*, while the hardest parts were Q8*(a)*(ii), Q6*(a)*(ii) and Q6*(e)*(ii) in that order.

It was pleasing to note that good knowledge of half-life, shapes of molecules, preparation of a standard solution and Le Chatelier's principle was shown by a significant number of candidates.

It was also pleasing to note that a significant number of candidates performed well in many familiar calculation questions, e.g. Q4*(b)*, Q5 and Q8*(c)*(i). However, the calculations that were different were poorly answered, e.g. Q6*(e)*(i), Q7*(c)* and Q8*(a)*(iii). This shows that candidates' understanding of numerical concepts is lacking in depth. This is further borne out by the difficulty many seemed to have had in converting from one unit of measurement to another and in rearranging the subject of a formula.

Although bonding is a staple GCSE topic, the questions on dot and cross diagrams and the relationship between physical properties and bonding were generally poorly answered. It is apparent that some candidates have made little progress in understanding from GCSE level.

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

Atebion Cyfrwng Cymraeg

Safodd ychydig tua 7% o'r ymgeiswyr y papur trwy gyfrwng y Gymraeg. Nid oedd llawer o wahaniaeth rhwng y papurau Cymraeg a'r papurau Saesneg. Roedd safon atebion Adran A ychydig yn well ond nid oedd safon yr atebion i'r cwestiynau mathemategol cystal. Mi roedd y mwyafrif o atebion anghywir yn dilyn yr un patrwm a'r canolfannau Saesneg.

Roedd ymgeiswyr yn defnyddio'r termau Cymraeg yn hyderus mewn gwaith estynedig a gwelwyd iaith raenus mewn llawer o'r atebion hirach, fel adnabod hydoddiannau halwynau Grŵp 2 a 7. Nid oedd iaith y cwestiynau wedi achosi unrhyw anhawster i'r ymgeiswyr. Diffyg gwybodaeth a dealltwriaeth oedd y rheswm dros golli marciau ac nid yr iaith a ddefnyddiwyd ar y papurau.

Section A

This section was answered disappointingly with the mean mark being just under 5 out of 10.

1. Not the expected start. Under half the candidates gained both marks in this simple question on ionic bonding. A few lost a mark for not clearly showing electron transfer but far too many lost both marks for drawing covalent structures.

2. Poorly answered. Over half failed to gain any marks. 'Sodium and bromine' and 'magnesium and oxygen' were as popular as the correct answer. Even if a candidate chose the incorrect elements a mark was still awarded for a correct reason.

3. *(a)* Although many students correctly described a coordinate bond, the mark was lost by many as there was no reference to the covalent bond.

(b) Poorly answered. Around three quarters could not give an example of a coordinate bond.

4. *(a)* This question on electron capture was only fairly well answered. Many candidates thought that a rubidium isotope formed, while others placed the electron on the right.

(b) The half-life calculation was generally well done. The most common error was to take 6.87×10^5 years as the half-life, which gave the incorrect answer of 2 061 000 years.

5. This proved to be the best answered question of the whole paper with around three quarters scoring both marks in this isotopic mass calculation.

Section B

6. This question was the best answered question in this section.

(a) (i) Well answered with over half scoring at least two out of the three marks in this calculation on energy. The main errors were a failure to convert nm into m and using an incorrect expression for $f = c/\lambda$.

(ii) Very poorly answered. Candidates simply discussed the energy of the transition between n = 1 and n = ∞ and did not refer to the convergence limit, the respective frequency and its conversion to energy using $E = hf$. As a result the vast majority failed to score a mark.

(b) This question was about ionisation energy and was only fairly well answered.

(i) Only about a quarter scored both marks with around a half failing to score a mark. Common errors were a failure to mention ‘little or no extra shielding’ and stating 'increased effective nuclear charge'. Most candidates do not understand the term ‘effective nuclear charge’ and use it because they feel obliged to rather than because it is relevant.

(ii) More than three quarters scored at least one mark. The main error was not mentioning 'outer' electron.

(c) (i) Surprisingly only about 40 % gained both marks in this simple calculation on gas volume. The main reasons for losing marks were a failure to convert °C to K and using $pV = nRT$ instead of $V_1/T_1 = V_2/T_2$.

(ii) In this part candidates had to use $pV = nRT$ and while about a quarter gained all three marks, an equal number failed to gain any marks. Although some candidates lost marks for failing to rearrange the formula, the main error was the failure to convert cm^3 into dm^3. As stated in last year's report, converting units from one form to another is an important mathematical skill, which will be tested in this specification.

(d) Most students managed to score two marks here; either by illustrating the difference in structures of H_2O and BeH_2 with clearly labelled diagrams and/or explaining/listing the difference in outer electron arrangement. However, for the final mark, most discussed the difference in repulsion between bonding pairs and lone pairs, rather than linking the difference in shapes due to differences in the number of outer electron pairs. Consequently, few scored the full three marks.

(e) (i) Many candidates did not realise that since the volume of water was 50 cm^3 the mass of ice was 50 g. Some did not know that density is equal to mass/volume.

(ii) Very poorly answered. Only about 20 % could explain why ice has a different density to water. Some stated 'there's more space in ice' without explaining further but many thought that ice was denser than water. Unfortunately the statement 'ice is solid, water is liquid' was frequently seen.

7. *(a)* A very good discriminating question with the whole range of marks seen and around a quarter gaining the full six marks. The main error in the calculation was use of an incorrect M_r value for sodium carbonate. In the description of how to prepare the solution, candidates lost marks for neglecting to say that the solid is dissolved in less than 250 cm^3 of water and that the solution in the volumetric flask should be mixed well by inverting the flask.

(b) (i) Poorly answered. Too many candidates took a mean of all four titres and an answer of 26.31 cm^3 was often seen. Many of those who chose the correct titres gave 26.2 cm^3 as an answer rather than 26.20 cm^3 despite all the figures in the table being quoted to four significant figures. Those who only averaged titres 1 and 3 or 3 and 4 were given credit.

(ii) Again poorly answered. Despite the question stating that **each** reading had an uncertainty of ±0.05 cm^3, most candidates seemed unaware that both the initial and final readings in titration 4 had to be considered and so the most common answer was 0.19 % instead of the expected 0.38 %.

(iii) This part was about errors in carrying out titrations and it was well done with marks being awarded for sensible ideas relating to the burette and the actual titration. Some dropped a mark for a vague cause and a more accurate/detailed effect (and vice versa). However a significant number misinterpreted the question and gave reasons resulting from making up the original solution, e.g. incorrect weighing, not inverting the volumetric flask, etc. or to human error, such as spillage. Some lost both marks because they discussed the accuracy in reading the burette itself. Whilst this is an area for error, the question did specifically state 'apart from errors in reading the burette'.

(c) This question on a back titration proved to be one of the trickier calculations in the paper.

(i) Just over half the candidates gained a mark for calculating the number of moles of acid used. About 60 % of these gained a second mark for correctly multiplying by ten to calculate the moles of NaOH in 250 cm^3 and only half of these managed to calculate the number of moles of NaOH that reacted to score the full three marks.

(ii) Marks were mainly lost here for failing to use the 2:1 ratio or using an incorrect M_r.

8. *(a)* (i) Including the 4 in front of $CuFeS_2$ made balancing the equation easier. However, around half the candidates still failed to score the mark.

(ii) This should have been an easy mark since Cu is an exception to the rule of fully filling the 4s sub-shell before the 3d. However, again around half could not recall the electronic configuration of a Cu atom.

(iii) This proved to be the trickiest calculation in the paper with around two thirds failing to score a mark. Many simply calculated the percentage of Cu in $CuFeS_2$, while a significant number failed to calculate the M_r for $CuFeS_2$.

(iv) This redox question proved more demanding than expected, with the vast majority making at least one mistake. The main errors were:

- confusing oxidation and reduction with respect to oxidation numbers
- ignoring the oxygen's change in oxidation number
- incorrectly assigning sulfur's oxidation number in SO_2 as +2.

(b) About two thirds of candidates could explain that strong acids were fully ionised for one mark. However, they found it more difficult to describe a concentrated one. Most did not mention water, simply stating that a concentrated acid had a large quantity of acid or H^+ ions. Some described concentration rather than concentrated.

(c) (i) This was generally well attempted, with many achieving full marks.

(ii) Few two mark answers were seen here and with many did not see the link with part (i). Some gained a mark for showing that the pH gave the same H^+ concentration as the answer to part (i) but failed to link this to the teacher's comment in order to gain the second mark. Candidates who failed to carry out a calculation but realised that since the low concentration of H^+ in part (i) gave a very low pH, it must be a strong acid, gained one mark.

(d) Many candidates correctly interpreted and explained the shift in equilibrium, but failed to mention the colour change as a response for the observation, i.e. turns blue or yellow-green and so lost marks in both parts.

(i) Some candidates confused the addition of water with dilution and thought it made the colours lighter and did not affect the position of equilibrium. This gained no marks.

(ii) A common error was to refer to 'the endothermic side' instead of 'the endothermic direction'.

9. This was the least well answered question in this section.

(a) As expected a whole range of answers were seen in the quality of extended response (QER) question. Only a minority of candidates obtained a higher band mark with around 40 % scoring in the lower band. A significant minority did not attempt the question.

Most candidates could recall and apply the use of silver nitrate solution in identifying the five compounds provided. Many also recognised that sulfuric acid gives precipitates with barium solutions but its reactions with Ca^{2+} and Mg^{2+} were not as well known. The effect of adding sodium hydroxide solution to the compounds proved beyond most. The examiners accepted the difference in intensities of the hydroxide precipitates as a way of differentiating between the compounds and this helped some but not many. A few candidates drew tables with correct observations but did not make any additional reference to how the results could be used to identify each compound, so missed out on the higher band.

(b) Many candidates gained both marks although some lost a mark due to naming the colour incorrectly, e.g. red. However, a number of candidates tried to test for calcium ions by adding carbonate or sulfate ions to form precipitates and consequently gained no marks.

(c) Both parts were poorly answered with only around a third getting the mark in each case. A minority lost a mark for failing to give the state symbols, but most candidates did not have an idea how to write an ionic equation. At this level one would expect the majority to be able do this.

(d) Very poorly answered. A minority could identify the thermal decomposition or at least the compound losing carbon dioxide (gaining at least one mark). However most candidates incorrectly linked the loss of mass to the solid 'evaporating with the water'!

(e) This part was about how the properties of compounds/elements relate to the bonding present.

(i) This part was about ionic bonding and was very poorly answered with about three quarters failing to gain a mark. The most popular answer was 'calcium chloride conducts electricity when molten because it has a sea of electrons'. Many of the candidates who correctly referred to 'ions' instead of 'electrons' failed to state why it did not conduct in the solid state and so lost a mark.

(ii) This was easily the best answered part of the question. Most candidates knew that weak van der Waals forces are responsible for iodine’s low boiling temperature. However, many failed to make it clear that these forces are between iodine molecules and so lost a mark.

(iii) This was only fairly well answered. Many candidates lost a mark by mentioning magnesium’s sea of electrons but not the metal ions they surround. Only a minority could adequately describe how the metal could change shape.

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UNIT 2 – ENERGY, RATE AND CHEMISTRY OF CARBON COMPOUNDS

General Comments

The paper produced a range of marks with well-prepared candidates being able to demonstrate real understanding of chemical principles, practical techniques and the mathematical processes involved in chemistry at this level. Weaker candidates were able to gain some marks but often failed to gain credit because their answers did not actually address the question as set. Some candidates appear to see a certain word/phrase in a question and then answer it as though it said 'write all you know about ...' rather than addressing the specifics of the question.

There was no evidence that shortage of time was a factor in performance since there were few significant gaps in responses and most candidates attempted all questions.

Section A

1. *(a)* Most candidates drew correct formulae. These were accepted regardless of the bond angles shown.

(b) The vast majority of candidates drew a correct skeletal formula.

2. A few answers had incorrect numbers of hydrogen atoms but most formulae were correct.

3. Although it was apparent that most candidates recognised that the peak of the curve moved to the right, in some cases it was difficult to see whether the curve was lower than the original. Candidates should be advised to make the difference in height obvious.

4. Some candidates drew structures that were really sections of a polymer and some drew structures without a double bond but most clearly understood the principle of the polymerisation process.

5. Some candidates confused the order in which the reagents were added but most did include the use of silver nitrate and that a yellow precipitate was formed.

6. *(a)* Any unambiguous formula was acceptable. Some structures did not include the ester link or the branched chain for the alkyl group.

(b) The catalyst was generally known with only a small minority suggesting nickel or iron.

Section B

7. *(a)* Most candidates recognised that the enthalpy of formation involves the use of the elements. The most common error was incorrect balancing or incorrect/ missing state symbols.

(b) Only the most able candidates gave an acceptable reason. Most incorrect answers were based on loss of heat or that all the elements were not in their standard states or not all in the same state.

(c) (i) Perhaps, since it is unusual to ask about how the enthalpy change is **calculated** rather than the practical involved in its determination, many candidates wrote a lot of irrelevant information that did not answer the question. Most candidates however did realise that they should use energy = $mc\Delta T$.

(ii) As in part *(b)* only the most able candidates gave an acceptable response. A common answer was based on a comparison of the ease of combustion of ethane and ethanol.

(d) Although candidates had clearly carried out similar exercises, it did not appear that many had considered the effects of possible errors in practical technique. It was, for example, insufficient to state that Euan would have only a very small rise in temperature without also commenting on the effect of this on the magnitude of the error. In Carys' case, a specific comment on a larger mass of fuel being used or that the temperature could not rise above 100 °C was needed. The possible change in the mass of water due to evaporation was considered insignificant in this case.

(e) (i) Many candidates drew Hess cycles or used other acceptable methods to determine the enthalpy change. Common errors included the omission of the multiplying numbers or the reversal of the signs of the values.

(ii) The vast majority of answers compared the energy released per mole of fuel rather than the energy released for the same mass. For full credit it was necessary to comment on whether the data proved that Amir was correct or not.

8. *(a)* (i) Nearly all candidates clearly knew how to determine an empirical formula although some neglected to actually write it. Most also gave the correct molecular formula.

(ii) The link between the decolourisation of bromine and the presence of unsaturation was recognised by the majority of candidates. A significant number also calculated the mole ratio correctly but only a small number went on to recognise that this meant that one double bond was present.

(iii) This was generally well known.

(iv) This too was generally well known.

(v) Although **X** was expected to be one of the isomers of butene, answers were credited if they followed from the compound identified in part (i). In the second part, most answers seen were acceptable but some candidates, whilst clearly recognising that bromine adds across the double bond, inserted additional bromine atoms at other points in the molecule. In the final part compounds with any number of bromine atoms were accepted as long as those already included after the addition were still present. It was surprising how few candidates gave a correct answer here.

(b) This was the part in which the quality of written response (QER) was assessed. Most candidates sensibly looked at each spectrum and commented in turn on the significance of the data before coming to a conclusion about the identity of **Y**. To access the higher band it was necessary to suggest an identity for **Y** containing four carbon atoms and two chlorine atoms.

9. *(a)* Where a diagram of apparatus is required, the marks are generally awarded for showing understanding of its use and not for its artistic depiction. On that basis many weak diagrams gained credit. It was not acceptable to use a test tube as the reaction vessel since a volume 100 cm^3 of hydrogen peroxide was specified.

(*b*) (i) & (ii) Since the question specified that the graph had to be used and that there should be a clear indication of how it had been used, it was necessary to see that a tangent had been drawn for full credit to be awarded. However, since it is difficult to draw tangents accurately, in this and in part (ii), considerable tolerance in the actual rate calculated was allowed.

(iii) At AS, vague statements about there being fewer particles to react are not sufficient. For full credit the significance of concentration and collision frequency were needed.

(iv) Most candidates used the graph to find that 2000 cm^3 of oxygen were produced in the reaction. Most also used the information in the data booklet to find that 1 mol of gas has a volume of 24.5 dm^3 under the conditions specified but a few did use 24.0 dm^3. Many correct answers were seen although some candidates failed to multiply by 2 whilst others failed to multiply by 10.

(c) Most candidates gained some credit but few scored full marks. Since the question asked how the better catalyst could be identified it was necessary to state how this decision could be reached rather than just saying look for which one was quicker.

10. (a) (i) The basis of the mechanism was clearly known to the vast majority of candidates but marks were lost through lack of precision. Curly arrows, for example, must start and finish at the correct points.

(ii) As noted in Q8 most candidates were able to name the type of reaction mechanism.

(b) (i) Although a number of answers scoring full marks were seen, a significant number of candidates apparently did not realise that ethanolic sodium hydroxide produces alkenes from halogenoalkanes. A variety of products were suggested. A number of candidates did draw alkenes but did not realise that *E*- and *Z*- isomers are possible for but-2-ene.

(ii) Generally well known.

(c) The effect of CFCs on the ozone layer due to the formation of chlorine radicals was well known and whilst many candidates went on to describe the detrimental effects of its destruction, few were precise in their explanation of why HFCs are preferred.

11. (*a*) (i) Most candidates suggested that yeast should be added and that final separation would be achieved by fractional distillation. The need to allow the carbon dioxide produced to escape and to exclude oxygen was less well appreciated.

(ii) The atom economy of the reaction was generally calculated correctly.

(iii) A variety of factors could legitimately be considered worthy of credit but, for both marks, a comparison of each method of ethanol production was needed.

(*b*) (i) It was evident that nearly all candidates were aware that a primary alcohol had an —OH group with specific connectivity to the rest of the molecule but the mark was not awarded when it was not clear that the carbon to which this —OH was attached had to be considered.

(ii) Any unambiguous formula was accepted and a large number of candidates were awarded both marks.

(iii) In this part also many candidates gained all three marks. For full credit it was necessary to use **acidified** dichromate and, if the oxidation state was included, it had to be correct.

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UNIT 3 – PHYSICAL AND INORGANIC CHEMISTRY

General Comments

This was the first Unit 3 examination for this new specification and it was clear that some candidates found the increased mathematical demand a significant challenge. The majority of the A level mathematical content is found in Unit 3 rather than Unit 4 and this was reflected in the papers. The paper was taken by 1960 candidates and the mean mark was 35.9 which is lower than that typically seen in the CH5 unit of the previous specification. However, almost all candidates were able to access a range of questions throughout the paper and marks ranged from 3 to 74 out of 80.

It is pleasing to note that some of the new content in the course such as the Arrhenius equation was accessible to many candidates. Questions requiring candidates to select appropriate information or to link ideas from different parts of the specification to reach a conclusion were those that challenged candidates most.

Papurau Cyfrwng Cymraeg

Gwnaeth tua 130 ymgeisydd gwblhau'r arholiad cyfrwng Cymraeg. Yn y Gymraeg a'r Saesneg mae cywirdeb iaith, yn enwedig iaith a thermeg wyddonol, yn allweddol. Roedd llawer o'r ymgeiswyr yn defnyddio iaith raenus a chywir yn eu hatebion, a phrin iawn oedd y defnydd o dermeg Saesneg. Yn anffodus roedd rhai yn defnyddio iaith aneglur neu dermeg wallus, ond gwelwyd yr un lefel o wallau yn y ddwy iaith. Roedd effaith camddefnydd o dermau ac iaith aneglur yn fwy amlwg wrth ateb rhai cwestiynau.

8. *(b)* Roedd rhai yn trafod elfennau yn ffafrio cyflyrau ocsidiad penodol yn hytrach na thrafod sefydlogrwydd y cyflyrau ocsidiad. Roedd eraill yn nodi grymoedd van der Waals rhwng atomau yn hytrach na moleciwlau. Mae'r camddefnydd o'r termau atom, moleciwl ac ïon yn wall sydd wedi gwella dros y blynyddoedd diwethaf ond mae'n parhau yn broblem i rai.

9. *(c)* (ii) Roedd rhai yn cyfeirio at y niferoedd o atomau ar ddwy ochr yr ecwilibriwm wrth drafod effaith gwasgedd heb ddeall bod nifer yr atomau yn gyson – nifer y moleciwlau sy'n newid.

11. *(b)* (i) Defnyddiwyd 'bromin' yn lle 'bromid' gan nifer yma a chollwyd marc amdano. Rhaid i ymgeiswyr ddeall y gwahaniaeth rhwng yr ïon bromid a'r atom bromin.

Section A

1. *(a)* This part was well answered.

(b) The majority of candidates were able to write an appropriate equation, however it was surprising to see a minority writing equations that included the spectator ions or equations that were not balanced.

2. This was generally well answered, with iron in the Haber process and nickel in the hydrogenation of alkenes being the examples used by the majority. The most common errors were to give Fe^{2+} or Fe^{3+} as catalysts for the Haber process or give compounds such as vanadium(V) oxide rather than metals.

3. The better candidates calculated the standard enthalpy change of solution and linked this to solubility, whilst some others gained the marks for comparing the enthalpy changes listed using clear terminology such as 'less negative' or 'more positive'. Weaker candidates used terms such as 'smaller' or 'bigger' leading to answers which were not totally clear.

4. Most gained both marks here, with the most common errors being a lack of standard conditions for concentration or pressure. A few gave '1 mol H^+' rather than '1 mol dm^{-3} H^+' and did not gain this mark.

5. *(a)* This was answered correctly by most but a significant minority included 46 s in their calculations despite this being far from all other measurements.

(b) This was poorly answered, despite iodine clock experiments being included in the specified practical work. Many included the concentrations in their calculations and only a minority realised that rate = 1/time for an iodine clock experiment.

6. Almost all candidates gained this mark

Section B

7. *(a)* This was poorly answered. Many candidates gave a description of a weak acid and the most common answer was to say the base was a species that was partially dissociated which did not gain the mark.

(b) The answers to this question were of variable quality. The meaning of a buffer solution was vague in many answers, with some describing what was in the mixture which was simply repeating the question. In describing the mode of action of a buffer the better candidates gave the reversible reaction of the ammonium ions and the irreversible dissociation of the ammonium chloride. Weaker candidates gave the ammonium chloride as a reversible reaction and some gave HCl and ammonia as the products. Most were able to refer to the effect of acid and base on the equilibrium set up by the ammonium ions, however some referred to the equilibrium shifting to the left or right without giving the reversible reaction itself so it was impossible to give these answers credit.

(c) (i) Most candidates either gained both marks or none here. Candidates that did not know how to approach the problem chose pH values for a range of places on the curve with the values 11.1 and 5.5 being the most common.

(ii) Many candidates chose the correct indicator but some were unable to explain why. A common error was to say that the indicator matched the equivalence point with no further detail or reference to the sudden pH change or the vertical region of the graph.

8. *(a)* (i) Most gained marks on this question, with the formulae of the chlorides well known. The reasons given by most were correct, but reference to the inert pair effect was the most common error.

(ii) This was generally well answered and most were familiar with $AlCl_3$ and the dimer formed from it. Other species were also acceptable. It was disappointing to see dot and cross diagrams that lacked the lone pairs on chlorine.

(b) This is the first quality of extended response (QER) question that candidates have faced in the new A level chemistry course and the majority gained some marks although few attained the higher band. The information provided regarding the oxides referred to the acid-base properties, their redox properties and their physical states and to reach the higher band an answer was expected to cover at least two of these in detail, including relevant equations. The weakest answers simply repeated the information given in the text.

Most candidates could make some reference to the acid-base properties of the oxides although the link between non-metal (covalent) oxides and acidity was not mentioned in many cases. The idea of amphoteric behaviour was well known. The equations chosen to explain amphoteric behaviour frequently did not refer to PbO with many starting with Pb^{2+}(aq) or $Pb(OH)_2$ which were not relevant to the question. It was disappointing to see CO or PbO_2 appearing in incorrect equations in this section. Some candidates also gave equations producing insoluble lead compounds such as $PbCl_2$ in solution.

The redox properties were often poorly explained. Most could state that the +4 oxidation state is more stable in carbon and +2 in lead, but some simply stated that CO_2 was more stable than CO. Explanations of the patterns in stability were of variable quality. Discussions of elements preferring oxidation states with no reference to stability did not gain full credit as they do not use scientific conventions and vocabulary accurately. The weakest answers either gave incorrect oxidation states or referred to octet expansion. The equations for CO as a reducing agent and PbO_2 as an oxidising agent were frequently incomplete or incorrect.

Few candidates chose to discuss the physical states. The explanation of the gaseous states of CO_2 and CO was generally clear with only very few discussing the breaking of covalent bonds. Fewer were able to link the physical states of lead oxides to ionic bonding.

9. *(a)* This was generally well calculated, although a few candidates neglected the idea of the percentage and obtained an answer that was 100 times too great. Some candidates gave their answers to two significant figures and were penalised for this.

(b) (i) The vast majority were able to do this although a few candidates neglected the need for square brackets and were penalised.

(ii) I The two most common answers here were CS_2 (the correct answer) and C_6H_6. The calculations of the relevant concentration of NO_2 caused problems for some, with a range of answers seen. Where candidates failed to include the factor of two from the chemical equation they obtained a value for K_c of 2.01 and the answer benzene which was credited with 2 marks. It was very disappointing to see candidates calculating values which were far from those in the table and not showing an understanding that this did not match any solvent listed.

II This question expected candidates to link ideas from differing parts of the specification and a significant number found this difficult.

(c) (i) This question expected candidates to link the ideas of catalysts from their rates work to equilibria. Some weaker candidates said catalysts did not affect the position of equilibrium which is correct but did not answer the question. Others simply gave the definition of a catalyst.

(ii) Most candidates gained marks here, although the explanations given sometimes lacked detail. An answer of 'use a lower temperature as it is an exothermic equilibrium' was not sufficient to gain the mark for explanation.

10. *(a)* Most were able to do this although the oxidation states in NOCl challenged some candidates.

(b) Most recognised that Cl_2 was an element, but not all stated that this needed to be in its standard state.

(c) Many gained marks here although only a minority gained both. Errors included leaving the enthalpy change of the reaction out of the calculation and forgetting the need to double or triple values when the stoichiometry requires it.

(d) (i) Most gained marks here, although the need to interconvert units caused problems for some. The majority converted the temperature to Kelvin but the conversion of entropy to $kJ\ K^{-1}\ mol^{-1}$ was often neglected.

(ii) Many realised that the change of state would lead to a change in entropy and how this would affect the Gibbs free energy.

(e) (i) Most could calculate this although some attempted to use $-\log(0.3)$ rather than $10^{-0.3}$.

(ii) This question challenged many but most chose titration as the more appropriate method. It was disappointing that candidates with some understanding failed to make a comparison and simply stated that titration measurements were to 3 significant figures without any reference to the pH probe. A similar problem was seen with those who focused on the logarithmic nature of the pH scale without reference to titration.

11. *(a)* Most candidates could select appropriate information calculate the value of d as 4.

(b) (i) Most identified the compound as containing bromide but many stated bromine and were penalised. Over half linked the halide to the lack of hydrogen sulfide smell but weaker candidates linked it to the coloured fumes without realising these were possible with iodide as well.

(ii) Many candidates divided the mass of the precipitate by the A_r of bromine rather than the M_r of silver bromide and this led to an incorrect answer.

(c) Most recognised this as a sign of amphoteric properties.

(d) A significant minority of candidates did not know how to approach this question and did not refer to the elemental analysis data that was given in the table. Those that used this data generally gained the mark and the formula given was credited as long as it followed from their earlier answers.

12. *(a)* This was expected to be a relatively straightforward question however only a minority gained the full three marks. Common errors included incorrect charges on **C** and **F**, incorrect numbers of ammonia or hydroxide ions in **A** and **C** and identifying **E** as iodide or even potassium sulfate. A statement that **D** was copper iodide with no reference to oxidation state was not accepted, although the formula CuI was given credit.

(b) Many referred to incomplete *d*-orbitals here without indicating that the energy of each electron in the *d*-subshell had a similar energy or ionisation energy.

(c) Most gained one mark here for noting that the bromate(V) could oxidise the vanadium due to its more positive standard electrode potential. Fewer realised that the bromate would further oxidise the bromide to bromine. Some stated that bromate(V) would be the major species as it was in excess however the question asked for a product so bromate(V) was not accepted.

(d) Candidates that could convert pH to a concentration of hydrogen ions were able to gain three marks here for their explanations. Candidates that did not make this change struggled to gain credit.

(e) This is the first question including the use of the Arrhenius equation and it was pleasing to see that most candidates were able to gain marks here. Two sets of data were provided to guide candidates to the range of the possible answers as k had to be between 0.0761 and 0.2873. The weakest candidates simply gave the midpoint of these values and gained no marks. The majority of answers were either the correct value or included one error only. The most common error was to forget that R used energy in J but the activation energy used kJ so a factor of 1000 was needed. Candidates that did this gained three marks.

(f) This question challenged many although a number of candidates were able to link the colour change to the end-point or the indicator being hidden by the colour of the transition metal ions. The weakest candidates focused on pH. Very few were able to explain how colorimetry could identify the point at which one substance was no longer present by finding a frequency absorbed only by that substance.

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UNIT 4 – ORGANIC CHEMISTRY AND ANALYSIS

General Comments

This was the first occasion that this paper has been set and it was clear that, for some candidates, a number of question parts proved to be challenging. This was partly due to the requirement that the mathematical content of the papers overall at this level needs to be 20 % and that the number of questions needing an element of application is higher, together with a subsequent reduction in those questions needing only recall answers. Some questions too, had a focus on the practical aspects of the qualification.

This 80 mark paper was designed to take one and three quarter hours. Although, with more focus on application questions, it was inevitable that more reading was necessary there was little evidence that the paper was too long and that candidates had to rush their answers.

Some excellent work was seen, with evidence of careful revision from both the sample material and from CH4 papers from the previous specification. As in the past, some of the weaker candidates clearly had to resort to guessing what the particular reagent required might be. The examiners hoped that candidates had been given the opportunity to show what they had learnt in the A2 year of the course and were also able to apply material that had content from the AS year.

Section A

1. Some candidates stated that a purple/violet precipitate is produced when aqueous phenol is added to a solution of iron(III) chloride. A number wrote that a white solid is produced when aqueous phenol is added to a solution of sodium hydroxide, rather than no observation/change.

2. Questions that ask candidates to provide an empirical formula seem to cause problems and a number of errors were seen in these responses. A common error was to write the empirical formula as C_2H_3O, having incorrectly worked out the molecular formula as $C_6H_9O_3$.

3. The reaction of sodium 2-hydroxybenzoate with soda lime gives phenol and sodium carbonate as the products. Although many candidates gave phenol as a product, fewer gave sodium carbonate. Questions on decarboxylation seem to continue to cause problems.

4. A number of candidates misread the question as an oxidation process and gave an oxidising agent instead of the expected sodium tetrahydridoborate(III) or lithium tetrahydridoaluminate(III).

5. This question asked for the answer to be given to an appropriate number of significant figures. Since the numbers in the question were given to two figures, it was expected that the answer would also be given to two figures. As a result 27 % was the appropriate answer.

6. A considerable number of wrong answers were seen. The most common error was to state that the compound was pentanoic acid. Careful reading of the question would have suggested that the compound was the ester, 1-propyl ethanoate, as propan-1-ol was produced on alkaline hydrolysis. Some gave ethyl propanoate.

7. Many candidates correctly gave the displayed formula of cyclohexyl ethanoate. A few candidates could not resist putting a circle in the alicyclic ring, which was marked wrong. Among common errors were the omission of some hydrogen atoms, five-bonded carbon atoms and formulae including only one oxygen atom.

8. A number of scripts were seen where the candidates could not remember the reagent(s) necessary to convert an amine group to an alcohol group. Of the wrong suggestions, sodium hydroxide was the most commonly suggested reagent. Candidates generally provided a suitable oxidising agent for the oxidation of hexane-1,2-diol to hexanedioic acid, however, sometimes the oxidising agent given was not acidified.

Section B

9. *(a)* (i) Many candidates suggested the use of PCl_3, PCl_5 or $SOCl_2$. Those who could not remember the correct reagent sometimes suggested $AlCl_3$ or HCl.

(ii) Compounds that are seen as colourless in white light are not absorbing any light in the visible region of the electromagnetic spectrum. A number of candidates stated that ‘it absorbs all the visible region’. This question proved to be challenging for many.

(iii) Candidates were required to work with the fragment that was lost – this had an 'M_r' of 100. The examiners expected a formula for a fragment that could be formed from the breakdown of DEET in the mass spectrometer. This formula could be a molecular formula or show some structure, for example $(CH_3CH_2)_2NCO$ or $C_5H_{10}NO$. Some candidates misread the question and worked with 91.

(b) (i) The usual oxidising agent for the oxidation of a methyl side chain on a benzene ring is alkaline potassium manganate(VII). The need for these alkaline conditions was sometimes omitted, with subsequent loss of credit.

(ii) Most candidates realised that the salt of the carboxylic acid was produced using alkaline oxidation and that acidification was necessary to produce the carboxylic acid.

(c) (i) The zwitterion structure of 2-aminobenzoic acid was generally given correctly. Sometimes the positive charge on the nitrogen atom was not given as close to the atom as it could have been.

(ii) The ester produced in the reaction has an $-NH_2$ group and this can act as a base, accepting a proton to give compound **T**. Although it appeared that some candidates knew this, they found it difficult to express their ideas clearly enough for credit to be given. Typical omissions included not specifically identifying the $-NH_2$ group and the vague mention of lone pairs without identifying where they were to be found.

(iii) I Most candidates gained this mark for stating that water was produced during the esterification or that it was present in the sodium carbonate solution.

II Ethoxyethane is very flammable and most candidates wrote that this could be safely removed by using a hot water bath or by using a heating mantle.

(d) (i) Nearly all candidates wrote correctly that 2×10^{-5} mol of BA was produced.

(ii) Some candidates did not use the information provided to give the expected answers. This was a discriminating question and it was unusual to award all three marks. The examiners were looking for the following three points.

- As BA is produced it dissolves **preferentially** in the hexane
- This moves the position of equilibrium to the right
- The 2-aminobenzoic acid remains in the aqueous alcohol

10. *(a)* (i) The majority of candidates identified at least one of the structures correctly. A number gave the formula of one of the reactants as containing a diazonium group. Those who wrote 2-hydroxybenzoic acid with the hydrogen atom of the phenolic –OH group bonded directly to the benzene ring were penalised.

(ii) Candidates were expected to link increasing pH with increasing wavelength with a reference to the colours given in the question. Very few were able to link these three features together and responses such as 'pH increases as the wavelength increases' were not credited.

(iii) Many candidates gained both marks here. Some lost marks for using an incorrect equation that linked frequency, wavelength and the velocity of light or a subsequent incorrect conversion of units.

(iv) A number of correct answers were seen but common errors included forgetting to use Avogadro's number and neglecting to convert J to kJ.

(b) (i) The reducing agents were nearly always correctly given.

(ii) This question was generally answered poorly with badly expressed answers. Only very few candidates scored the full three marks. Most identified the two environments but fewer identified each peak as a singlet as the protons in each of the environments were equivalent.

(iii) Many correct answers were seen here, with candidates realising that it was the carboxylic acid hydrogen that was replaced by sodium. Some also replaced the phenolic hydrogen. A few candidates suggested that the $–NH_2$ group was replaced by –OH.

(iv) This question asked for a dot and cross diagram for the hydroxyl radical. Some candidates lost the mark by adding a charge or for providing an incorrect number of outer electrons (often eight instead of seven).

11. *(a)* (i) Nearly all candidates gained the mark for nucleophilic addition. Marks were lost in the mechanism for not giving all the partial / full charges or for curly arrows going in the wrong direction. The curly arrow must always go from the relatively electron rich species towards the more electron deficient species.

(ii) The question asked about two specific stages – the extraction and distillation stages. Marks were awarded for identifying why these stages could have resulted in a reduced yield of the product.

(iii) This question was well answered with many candidates gaining all three marks.

(iv) The formula for the repeating section of the polymer was often written correctly but some candidates gave a structure that had three carbon atoms in the carbon backbone.

(b) Many candidates gave the correct formula for 3-hydroxypentanoic acid but then did not go on to balance the equation as requested.

(c) The differences between addition polymerisation and condensation polymerisation were well known but it was necessary to mention both types in the answer.

(d) (i) This was an easy mark for nearly all candidates.

(ii) Nearly all candidates gained at least one of the two marks available but some did not use the mole ratio correctly or failed to use it at all. This error often gave a relative molecular mass of 120.

(iii) The correct answer of 60 in part (ii) afforded candidates with the opportunity to give propan-2-ol here. Those who obtained 120 in part (ii) had a more difficult task with finding a suitable secondary alcohol that had an M_r of 120 and credit was given wherever possible.

12. *(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. Many candidates scored marks in the range 2 to 4 out of 6. Some excellent answers were seen with 6 marks being awarded to those who used all the information in a relevant and structured manner to arrive at the correct displayed formula for compound **W**.

(b) (i) Nearly every candidate correctly identified the chiral centre. Those who failed to do so usually chose the carbon atom closest to the benzene ring.

(ii) Many candidates could clearly explain the meaning of a racemic mixture. Some candidates lost the second mark for a lack of precision in their answer, although it was obvious that they knew what they were trying to describe.

(iii) This question asked for the formula of the dipeptide formed from L-DOPA. In general this question was answered poorly. A number of candidates were careless in writing the formula and some atoms were often omitted. Some candidates tried to involve the −OH group of the phenol and provided a formula where the chain contained an extra oxygen atom.

(c) (i) Although many candidates clearly understood the idea that the stability of the benzene ring structure would be lost if addition occurred, and that addition across the double bond was an easier option, a number of candidates lacked precision in their answer and lost the mark as a result.

(ii) Resveratrol is a phenolic compound and addition of aqueous bromine would not only add across the double bond but would also result in the substitution of bromine atoms in the rings. Many disappointing answers were seen here. Common errors seen included

- only one bromine atom being added across the alkene group (i.e. an addition of HBr)
- only one of the rings being brominated

13. *(a)* (i) A number of candidates gained one mark for identifying compound **N** but often lost marks for a lack of detail in their answer. A reference to the peak being described, its splitting pattern and what caused this splitting pattern was necessary to gain credit in each case.

(ii) I Many candidates suggested that (aqueous) bromine would be decolourised by the three alkenes but did not then go on to describe the effect with bromocyclobutane. As a result the mark was not awarded. The question did ask candidates to give the result of their test with **each** compound.

II Similarly the description of the ^{13}C spectrum for **each** compound was sometimes missing.

(b) This question was a good discriminator with a wide range of responses seen. Those who dropped marks often

- included incorrect charges (or failed to include them at all)
- did not start with a bromine molecule
- lacked precision in locating curly arrows (sometimes drawing them the wrong way round)
- omitted the catalyst

(c) (i) Although the calculation was often correct, marks were lost for giving an equation using a bromine radical or omitting hydrogen bromide as a co-product.

(ii) Reagent **F** was often identified as hydrogen cyanide.

(iii) Many candidates correctly identified reagent **G** as dilute sulfuric acid or hydrochloric acid. No credit was awarded for nitric acid.

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UNIT 5 – EXPERIMENTAL TASK

General Comments

The first running of the Experimental Task proved to be well managed by centres and offered all candidates an opportunity to show positive achievement.

The mean mark was 25 out of 30. Most marks lost resulted from differences between teacher and candidate titration values and from recording the qualitative observations in Part B.

Teacher-awarded marks (3 marks)

Nearly all candidates were awarded all three marks although some dropped marks were seen for either NOT working safely or NOT making up the solution accurately, both of which required some kind of teacher intervention.

Part A

Titration recording (6 marks)

Marks were lost here for omission of units and incomplete labelling (initial volume, final volume & titre) of the table.

All burette readings must be recorded to 2 decimal places.

Concordant titres should be selected and used in the calculation of the mean titre. The mean titre should be calculated and given correct to two decimal places.

Most candidates scored the full 6 marks for this section but many still dropped a few marks carelessly.

Titration accuracy (5 marks)

These marks were assigned by comparison of the candidate’s mean titre and the teacher’s results and provided a range of marks between 0 and 5. In cases where candidates' results seemed to be well grouped but not close to the teacher's results, marking was based on those values.

Part B

Observations (6 marks)

Most candidates scored at least 4 out of 6 for this section. The majority of lost marks resulted from

- failing to see that the white precipitate of zinc hydroxide dissolved in excess OH^-
- failing to note the brown solution AND white precipitate on reaction of copper(II) sulfate and potassium iodide
- incorrectly describing a pale blue precipitate on reaction of copper(II) sulfate with barium chloride

Analysis

Part A (6 marks)

Most candidates managed to score 5 or 6 marks in this section. Most lost marks arose from

- incorrect calculation of the M_r of $FeSO_4$
- over truncation in the molar calculations
- careless arithmetic in calculating the final percentage

Part B (4 marks)

Although most gained the three available marks for identifying the metal ions present in each solution, they did have to link to the correct observation. Some dropped a mark very carelessly by correctly identifying an ion but then giving an incorrect precipitate colour. Error carried forward (ECF) marks were awarded where candidates used incorrect observations from the results section in their analysis, for example, some did not observe the zinc hydroxide dissolving in excess sodium hydroxide but identified the zinc ions by stating that they give a white precipitate with excess sodium hydroxide.

The ionic equation with barium and sulfate ions was well attempted but many lost the mark for omitting the state symbols.

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UNIT 5 – PRACTICAL METHODS AND ANALYSIS TASK

General Comments

This was the first examination of this unit for the new GCE specification and 1930 candidates sat the paper. 132 sat through the medium of Welsh.

This 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 and a mean of 15.4 out of 30.

Atebion Cyfrwng Cymraeg

Ychydig yn is na 7% o'r ymgeiswyr safodd y papur trwy gyfrwng y Gymraeg. Roedd safon yr atebion yn debyg yn y ddwy iaith, gyda'r mwyafrif o atebion anghywir yn dilyn yr un patrwm. Nid oedd iaith y cwestiynau wedi achosi unrhyw anhawster ychwanegol i'r ymgeiswyr a diffyg gwybodaeth a dealltwriaeth oedd yn debygol o fod y rheswm dros golli marciau.

1. *(a)* It was pleasing to note that a number of candidates identified the need to use the ideal gas equation with the data in the table in order to calculate the number of moles of oxygen gas formed, before the volume of hydrogen peroxide could be calculated. An alternative method using Charles' Law to convert the volume of oxygen gas evolved at 22°C to volume at 25°C was also seen in a few scripts. The most common error in using the ideal gas equation was failing to convert the volume from cm^3 into m^3. Converting units is an important mathematical skill which will be tested in this new specification.

(b) (i) The majority of candidates gained three marks for suitable scales on both axes, correctly plotting the data and drawing a curve of best fit. However, in a small minority of scripts the curve did not start at the origin. The question asked for a calculation of the initial rate of reaction but a small minority calculated the rate at another point on the curve. Pleasingly, many candidates were able to calculate the rate competently, convert from $cm^3\,min^{-1}$ to $dm^3\,s^{-1}$ and express their final answer in standard form.

(ii) Generally, this question was well answered with most candidates recognising that the rate of decomposition of hydrogen peroxide would be twice the initial rate of oxygen formation.

(c) Reasonably well answered with over half of candidates scoring at least two marks out of three. They recognised that the rate of decomposition of hydrogen peroxide would halve if the concentration of hydrogen peroxide halved, and they were able to name at least one control variable in a practical investigation to show that the rate equation was first order with respect to hydrogen peroxide.

(d) Generally this question was well answered with candidates correctly describing an alternative suitable method for following the rate of decomposition of hydrogen peroxide. No credit was given for answers such as 'count gas bubbles' and 'follow change in pH'.

2. Although this question was not structured, the fact that the information was given in a tabular format meant that candidates could sensibly follow the order of the information in their responses. Thus, the most able candidates scored full or nearly full marks. However, the very weakest candidates were unable to access this question and some scored no marks.

Using the information given within method 1, one mark was awarded for identifying the Cr^{3+} ion and a further two marks given for the ionic equations for the formation of the $Cr(OH)_3$ precipitate and its dissolution in excess NaOH(aq). Incorrect charges and incorrect formulae such as $[Cr(H_2O)_6]$ or $[Cr(H_2O)_3(OH)_3]^{3+}$ were commonly seen.

Although gravimetric analysis is one of the specified practical exercises, only a small minority of the candidates could access the information given within method 2. Again, apart from the most able candidates, the ionic equation for the formation of silver chloride was not well done. The formula of silver chloride was often given as $AgCl_2$. Only the most able were able to show that the ratio of compound **W** to silver chloride formed was 1:1 and then apply this information to correctly identify compound **W** as isomer III.

3. This question clearly differentiated between those that had thoroughly revised the organic functional group tests and those that had not. Many excellent answers were seen to this eight mark question, as candidates worked logically through each of the four pairs of organic isomers to identify which reagent, from a given list of four reagents, could be used to distinguish between them.

Because each of the four reagents could only be used once it was not straightforward. One of the isomers in the first pair clearly showed an alkene C=C and a number of candidates incorrectly chose to use Br_2(aq) to distinguish between them. Although credited for a correct response for this first pair of isomers it meant that phenylmethanol and 4-methylphenol could not be distinguished with any of the remaining reagents and thus they scored a maximum of 6 marks.

It was disappointing to see that some A2 candidates were unable to score any marks for this question. These candidates were unable, for example, to identify the carboxylic acid functional group and state that effervescence would be seen if Na_2CO_3 was added. Similarly, they were unable to recognise the carbonyl functional group and state that a yellow/orange/red precipitate would be observed on addition of 2,4-dinitrophenylhydrazine.

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