GCE EXAMINERS' REPORTS

GCE
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SUMMER 2022

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CHEMISTRY

General Certificate of Education

Summer 2022

Advanced Subsidiary

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

General Comments

This was the first paper for three years and only candidates in year 12 sat the paper, consequently the number of entries was down from around 3900 to 2913. The mean mark was 35.9 (up 3.9 marks from 2019), the highest mark 79 and the lowest 1. In Section B the most successfully answered question as a whole was Q8 with Q10 being the least successfully answered. The most accessible parts on the entire paper proved to be Q8(a)(i), Q11(a)(i) and Q7, while the least accessible parts were Q8(b)(ii), Q11(e) and Q12(f)(ii) in that order.

It was pleasing to note that good knowledge of electron configuration, solid structures, oxidation numbers and aspects of performing a titration was shown by many candidates. Most candidates also showed a fair knowledge of radioactivity, metallic bonding and tests for ions.

A significant number of candidates performed well in familiar calculation questions e.g. Q4, Q7, Q11(b)(i). However, calculations that were slightly different were poorly answered e.g. Q9(d), Q10(b), Q12(f)(ii). This shows that candidates' understanding of numerical concepts is still lacking in depth and many still have a difficulty in converting from one unit of measurement to another.

Once again equation writing proved to be demanding for most candidates. Writing a chemical equation in Q11(a)(ii) was poorly done and writing an ionic equation in Q8(b)(ii) was very poorly done.

Comments on individual questions/sections

SECTION A

This section was fairly well answered, with the mean mark being around 6.5 out of 10.

Q.1 This dot and cross diagram question was supposed to be an easy starter and many candidates gained both marks. Some lost a mark for giving incorrect charges on the ions, but a significant number showed covalent bonding rather than ionic bonding and so failed to gain a mark.

Q.2 Poorly answered. Most candidates could give an example but less than half said that the atoms had to be electronegative.

Q.3 Very well answered with around three quarters giving the correct configuration.

Q.4 Just over half the candidates calculated the correct atom economy.

Q.5 Well answered. Over two thirds knew what was meant by a 'coordinate bond'.

Q.6 Fairly well answered with over a half scoring a mark in both parts.
In part (a) the most common error was to give ^{231}Pa.
In part (b) the most common error was to give ¼.

Q.7 This mole calculation was very well answered. Over two thirds gained both marks and a significant number gained one mark. The most common error was to multiply by the Avogadro constant.

SECTION B

Q.8 This question was the most successfully answered question in this section.

(a) (i) Almost all scored at least one mark with around three quarters gaining both marks. Some candidates confused iodine with ice while others confused sodium chloride with caesium chloride.

(ii) Surprisingly only just over a quarter of candidates scored both marks while around a half gained one mark. The main errors were stating that ice had a higher melting temperature than iodine and that cadmium had a higher melting temperature than graphite.

(iii) Very well answered. The main error was not being specific enough and just stating 'intermolecular bonds'.

(iv) Again, well answered. However, many candidates did not realise that the substances had to be chosen from the six substances given in the stem and named other metals.

(v) Fairly well answered. Most knew that the layers in graphite could slide over each other but fewer stated that this was due to the forces between layers being weak.

(vi) There was an improvement in the description of metallic bonding. Around three quarters gained at least one mark and around 30% gained all three marks. Many candidates gained the mark for the metal ions and delocalised electrons from a labelled diagram. However, some candidates described the bonding correctly but lost a mark due to an incorrect diagram. A few candidates referred to ionic or intermolecular bonding, but the main error was not stating that there was a strong force of attraction between the metal ions and the delocalised electrons.

(b) (i) About half the candidates knew that cadmium hydroxide would form a white precipitate. Fewer knew that cadmium sulfate would be a colourless solution.

(ii) This proved to be the most challenging part of the paper. Fewer than 1 in 5 candidates could write a correct ionic equation. This is very disappointing since ionic equations are also covered at GCSE. Some failed to balance the equation, others gave incorrect state symbols, but the majority did not know where to start.

Q.9 (a) Fairly well answered. The main error in part (i) was a failure to state that electrons were promoted in the first place. In part (ii) some candidates mixed up which spectrum had black lines or coloured lines.

(b) Poorly answered. Over half failed to score a mark. Common errors were using Planck's constant to calculate the frequency, failing to convert nm to m and failing to convert Hz to MHz.

(c) This question on equilibrium proved trickier than expected. Many candidates did not use the diagram and so lost a mark in both parts. Most could not apply Le Chatelier's principle, giving explanations that were too vague and that did not refer to equilibrium. Part (i) was better answered than part (ii).

(d) This proved to be quite a hard calculation. Although around 60% scored at least one mark, only around 10% obtained full marks. There were many common errors:

- not realising that 2 moles NaCl gives 1 mole Na_2CO_3
- not giving the answers to 3 significant figures
- not converting tonnes to kg or g correctly

Q.10 This question was the least successfully answered question in this section.

(a) In the QER question only a small minority of candidates obtained a higher band mark, with most scoring in the lower band. The mean mark was 2.1.

A large number knew that Group 1 metals were more reactive and some could explain why. The description of potassium's reaction was well known and that of calcium fairly well known. However, a significant number also described the reactions of sodium and lithium. They gained no further credit for this.

Only a minority could write balanced equations for the reactions, with many thinking that the oxide formed rather than the hydroxide. Many candidates were confused about the solubility of the carbonates with a significant number either thinking that both sets were soluble or both sets were insoluble.

(b) Again, this calculation proved difficult with only around 1 in 5 getting all 3 marks. Many candidates used $pV = nRT$ instead of $n = \frac{V}{V_m}$ and lost marks by using incorrect units. A very common mistake was to try and calculate the number of moles by dividing the mass of the impure sample by the molecular mass of the pure potassium carbonate. Most candidates who correctly calculated a mass for potassium carbonate gained the mark for calculating the mass of the impurity.

(c) Although the majority of candidates knew the test for either the potassium ions or the chloride ions, only just over a third gave both tests to obtain two marks.

(d) Poorly answered. Many candidates failed to gain a mark. In many cases marks were lost due to inability to express ideas precisely, rather than a lack of knowledge. Many simply stated that 'too much energy is needed' without referring to the second electron or that 'the second electron is removed from a new shell' without adding 'nearer to the nucleus'. Candidates referred to 'extra stability due to a full outer shell of electrons' gained no credit.

Q.11 (a) (i) Very well answered. About three quarters could deduce the oxidation number.

(ii) Poorly answered. Only around a third could write the correct equation. Many candidates could not give the correct formula for iron(III) oxide. A significant number ignored the products given in the stem and made up their own compounds.

(b) (i) Fairly well answered. Most correctly calculated the moles of arsenic oxide and over half the candidates scored at least 2 marks out of 3. The main errors were:

- not doubling the moles of arsenic oxide to get the moles of arsenous acid
- not multiplying the moles by 10 to change to dm^3
- truncating the final answer to 1 significant figure

(ii) Although this was a simple calculation with candidates only having to use $[H^+] = 10^{-pH}$ less than half gave the correct answer.

(c) Many candidates gained two marks by simply stating the shape and number of electron pairs and lone pairs. Fewer could suggest why this shape was formed to gain the third mark. A significant number failed to gain any marks.

(d) This calculation on $pV = nRT$ was fairly well answered. Over 1 in 4 gained all 4 marks but around half the candidates failed to score a mark. As in previous years many failed to convert cm^3 to m^3 and some failed to rearrange the equation correctly.

(e) The presence of phosphorus in the compound confused most candidates. In part (i) only about 1 in 4 could correctly identify the peak. A minority knew that it was PCl_2 but failed to specify which isotope of chlorine was present. Only those who gave a correct answer to part (i) tended to score any marks in part (ii).

Q.12 (a) Poorly answered. Not many candidates realised that ‘error 1’ was incorrect. Most thought that the weighing bottle should have been weighed before adding the carbonate or that the bottle should be washed after the carbonate had been transferred to the beaker. More candidates realised that ‘error 2’ was genuine and that the beaker should be rinsed out.

(b)-(d) Well answered. Over three quarters knew why an indicator was added and around two thirds knew why a rough titration was carried out and what was meant by ‘concordant’.

(e) This was disappointing. It was surprising to see that many candidates failed to read the burettes correctly, especially the final reading of the second titration. Another mistake was to write the readings to one decimal place in the table, despite six readings already being given to two decimal places. Also, many candidates included the value of the second titration in the calculation of the mean titre despite it being 0.35 cm^3 lower than the other two values.

(f) (i) This was a straightforward moles calculation using $n = cV$ but only around 1 in 5 candidates used the mean titre to calculate the moles of acid first. A few more used the 2:1 ratio to gain one mark.

(ii) About 40% gained a mark for deducing that 1.25 g of carbonate was used. A significant number of these divided the mass with their answer from part (i) to give a very large M_r and so only gained one further mark. Only a minority realised that they had to multiply their answer to part (i) by 10 before dividing to give a sensible M_r and gain further marks.

Summary of key points

- When writing ionic equations for a precipitation reaction as in Q8(b)(ii), only include the precipitate on the right-hand side and the two relevant ions on the left-hand side. One ion will be positive and the other negative. The ions will always be in an aqueous state and the precipitate will be a solid.

- When using Le Chatelier's principle as in Q9(c), make it clear that the position of equilibrium moves to the right or left not that the system moves.

- Successive ionisation energies always increase because the same number of protons are holding fewer and fewer electrons. A large increase in successive ionisation energies will prevent a new ion from being formed [Q10(d)]. Large increases occur when an electron is removed from a new shell nearer to the nucleus because the outer electron is closer to the nucleus, there is less shielding and an increased effective nuclear charge.

- When reading a burette as in Q12(e) always read the scale downwards. When filling in a results table for a titration always record to two decimal places. The last decimal place must be a '0' or '5'.

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UNIT 2 – ENERGY, RATE AND CHEMISTRY OF CARBON COMPOUNDS

General Comments

Based on available evidence from exam analysis and feedback from examiners, the paper proved to be accessible for most, with all questions being attempted by over 80% of candidates and majority being attempted by over 90%. They had generally prepared well for the exam, although too many were still lacking the knowledge for answering basic recall questions. This is evident in parts Q1(b), Q3 and Q5 which were done particularly poorly. Other candidates had prepared well but their responses lacked detail which led to marks being lost when answers were missing key elements. This is evident in parts Q6(b)(ii), Q7(a)(i) and Q10(c)(i).

It was good to see improved performance in the organic analysis question [Q8] with many obtaining 9 or 10 marks. However, several candidates performed very poorly as well, leading to a lot of variation in the marks. Many candidates also performed well in the calculation of enthalpy changes [Q10(a)], although Q10(a)(ii) proved to be a good example of candidates being unable to apply their knowledge in an unfamiliar context. This lack of application was also evident in Q1(a)(ii), Q6(b)(i) and Q10(b).

Finally, there were a number of candidates who did not take enough care to read the questions properly, sometimes leading to completely irrelevant answers e.g. Q7(b)(iv)II., Q9(b)(i), Q9(c), Q10(a)(iii) and Q10(c)(ii).

Comments on individual questions/sections

SECTION A

Q.1 (a) (i) Approximately three quarters of candidates answered this question correctly. The most common errors included only giving a single colour and giving a colour change of orange or brown to colourless.

(ii) This question was not well answered for such an early question, with a little under half of candidates answering correctly. Many responses gave the product for the addition of HBr to propene, although other common errors included incorrect number of carbon atoms in the chain and the double bond being left in the carbon chain.

(b) Just over a quarter of candidates answered this question correctly. The most common errors included halogen solutions (including bromine!), potassium dichromate and sodium hydroxide.

Q.2 (a) Many candidates answered this question correctly. The most common errors included drawing the shape of the s-orbital incorrectly, drawing a d-orbital and drawing an ‘arrows in boxes’ representation of a random electronic structure.

(b) Most candidates answered this question correctly. The most common errors included hydrogen, intermolecular, Van der Waals, covalent and sigma.

Q.3 Just over half of candidates obtained at least one mark in this question, with almost half of these candidates obtaining both marks. Many gained full marks for adding a hydrogencarbonate/carbonate and observing effervescence. Very few candidates obtained one mark, as the candidates who knew the test to use almost always knew the correct observation. The most common errors included halogen solutions (most commonly bromine), potassium dichromate, sodium hydroxide and potassium manganate(VII).

Q.4 Most candidates answered this question correctly. The most common errors included omitting the bonds extending either side from the repeating unit, leaving the double bond in the repeating unit and addition of hydrogen.

Q.5 Just over half of candidates obtained at least one mark in this question. The most common errors included omission of reference to one mole of a substance, omission of reference to elements being their standard states.

SECTION B

Q.6 (a) (i) Less than half of candidates gained this mark. The most common errors included circling the bromine atom, circling the entire HBr molecule and circling the double bond in but-2-ene.

(ii) Just over half of candidates answered this question correctly. The most common errors included homolytic, Van der Waals and electrophilic addition.

(b) (i) Few candidates answered this question correctly. It was clear that most had not familiarised themselves with this mechanism. Candidates who only obtained one mark almost always scored the mark for correct dipoles. Many attempted to show the substitution but used arrows to show the movement of atoms rather than the movement of the electron pairs.

(ii) Very few candidates obtained both marks for this question. Common errors included omission of ‘aqueous’ sodium hydroxide and giving conditions without any reagents.

(iii) Almost all candidates answered this question correctly. The most common errors included primary and naming another functional group, such as carboxylic acid or aldehyde.

(c) (i) Few candidates answered this question correctly. The most common error was naming acidified potassium manganate(VII) as a catalyst. A small number of candidates lost this mark by naming it as both an oxidising agent and a catalyst. This considered to be a right/wrong situation with no credit awarded.

(ii) Very few candidates obtained both marks for this question, but some obtained one mark for stating that butanone has a lower boiling point than butan-2-ol. Common errors included not comparing the boiling points, stating that butanone cannot be oxidised further and omitting the explanation in terms of hydrogen bonding.

(d) (i) Few candidates answered this question correctly. Many incorrectly answered the question by referring to atom economy, indicating that many are unsure of the difference between yield and atom economy. Some candidates tried to explain the low yield by stating that the two-step synthesis had a lower rate.

(ii) I. Many candidates answered this question correctly, with elimination being a more common answer than dehydration. Common errors included condensation, nucleophilic substitution, hydration and electrophilic addition.

II. Most candidates showed good understanding of the naming of organic molecules in this question. Some candidates also recognised the need for identifying and naming the two geometric isomers of but-2-ene. The most common error was the drawing and naming of methylpropene as a possible product.

Q.7 (a) (i) Just over half the candidates answered this question correctly. The most common error was making no reference to structure.

(ii) Almost all candidates obtained at least one mark on this question, with two marks being most common. There was no one part of this question that was done significantly worse than the others.

(iii) Many candidates obtained at least one mark on this question, with the mark for relating boiling point to chain length being by far the most common. Common errors included not naming the type of intermolecular force and naming it incorrectly.

(b) (i) Just over half of candidates obtained both marks on this question, with very few obtaining only one mark. Common errors included giving an incorrect formula for hexane, incorrect products (e.g. carbon monoxide) and incorrect balancing.

(ii) This question was done particularly poorly, with few candidates even obtaining one mark and almost no candidates obtaining two marks. Candidates who scored one mostly gained the mark for the compounds having the same number and type of bonds. Very few referred to the energy absorbed and/or released being similar.

(iii) Less than half of candidates answered this question correctly. Although many recognised that the branching influenced ease of ignition, most seemed to think that branching increased the reactivity of the alkane by making the bonds weaker.

(iv) I. Most candidates obtained at least one mark from this question, but less than a quarter of candidates were gained all three. Candidates usually lost marks by counting the number of bonds incorrectly, leading to one or both energy values being calculated incorrectly. Most candidates obtained the final mark as an error carried forward.

II. Less than half of candidates obtained one mark from this question and very few gained both marks. Many referred to the formation of carbon monoxide, which was not accepted as the question explicitly asked for an answer relating to enthalpy change. Almost no candidates made a quantitative comparison between the two enthalpy values.

III. Most candidates obtained the mark for this question. Common errors included reference to carbon dioxide, to causing global warming and to negative effects on breathing or lungs.

Q.8 Most candidates scored between three and five marks in this question by correctly analysing the data provided and explaining features of the unknown compound based on the analysis. A significant number gained eight or nine marks as there were more than ten marking points available. The unknown compound had to be identified correctly in order to score full marks.

Q.9 (a) Most candidates answered this question correctly. The most common errors included calorimetry, mass spectrometry and infrared (IR) spectrometry.

(b) (i) Most candidates scored at least one mark in this question, with just under half obtaining both marks. Candidates who only obtained the first mark lost the second due to insufficient description of the end point or by describing how a catalyst works (which is irrelevant to this question).

(ii) Almost half of candidates obtained two marks in this question. Very few obtained only one mark, as those who knew that they needed to calculate the gradient between zero and ten seconds were able to do so successfully. The most common error in this question was to calculate a mean over a period longer than ten seconds.

(iii) Just over half of candidates obtained this mark. Common errors included using $50cm^3$ as the volume of the catalyst and failing to convert the volume to dm^3.

(c) It was clear that most candidates had some understanding of the relationship between rate and temperature and catalyst, with many candidates obtaining at least three marks. Many used the Maxwell-Boltzmann distribution(s) correctly to support their answer effectively, although a small number became confused and drew an entirely different curve when a catalyst was used. Many candidates lost marks by referring to the total number of successful collisions instead of successful collisions per second or chance of successful collisions. Also, a few candidates obtained very low or no marks due to giving an answer based on changes in concentration and/or surface area, demonstrating that they had not read the question properly.

Q.10 (a) (i) Most candidates answered this question correctly. A few candidates lost marks due to an incorrect choice of scales or omitting the lines of best fit.

(ii) Few candidates recognised the correct way to calculate the maximum temperature rise by extrapolating the line back to the y-axis. This is most likely due to the unfamiliar context of the question as it did not involve taking temperature readings before starting the reaction. The question was marked generously because extrapolation took the line off the grid for the most commonly chosen scale.

(iii) Most candidates were able to obtain at least one mark for calculating the heat energy released by the crystallisation. Many also correctly calculated the number of moles of sodium ethanoate used. Few candidates recognised that the total mass of the system was the mass of water and sodium ethanoate combined in this unfamiliar context.

(iv) Just under half of candidates answers this question correctly. Many who answered incorrectly were confused by the use of theoretical enthalpy change in the question as they gave answers such as theoretical values only use bond enthalpies, theoretical values are averages and theoretical values are just predictions and can be wrong.

(b) Less than half of candidates scored any marks on this question, with very few obtaining two marks. Those who scored one mark did so by giving the correct formula of ethanoic acid. Very few candidates recognised that sodium hydrogencarbonate was the only base that would complete the equation as given. A small number of candidates gave sodium carbonate as the base, which was credited if the candidate also balanced the equation correctly.

(c) (i) Less than half of candidates scored any marks on this question, with very few obtaining both marks. The most common error in this question was for candidates to give a chemical test for a carboxylic acid. Another common error was the omission of ethanol from the list of reagents. Credit was given for the second mark if candidates provided a suitable oxidising agent and the correct observation associated with it.

(ii) Less than half of candidates scored any marks on this question, with very few obtaining all three marks. Those who obtained no marks usually did not recognise that the reaction should be done under reflux and so essentially re-drew the original diagram with some minor changes. Other common mistakes included drawing a distillation, not labelling the flow of water in and out of the condenser, blocking the condenser with a line going across the top or bottom and drawing a thermometer down the middle of the condenser.

Summary of key points

- Candidates must revise their subject knowledge more thoroughly to be able to access the marks.
- Questions need to be read more carefully, particularly any key information highlighted in bold or as part of a table. Many candidates lose marks through not reading the question properly and, instead, focus on one or two particular words that lead them to give a completely irrelevant answer.
- Candidates should be prepared to adapt their knowledge and experience in chemistry to contexts that are unfamiliar but share key similarities. Questions that require candidates to make small changes to a method or apply their knowledge to unfamiliar compounds are often answered poorly.
- Candidates should be encouraged to develop a deeper understanding of what is represented by certain diagrams and spectra. A good example of this is the drawing of mechanisms, where candidates have a limited understanding of what the curly arrows represent.

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UNIT 3 – PHYSICAL AND INORGANIC CHEMISTRY

General Comments

This was the first Unit 3 exam following a two-year hiatus and so candidates were much less familiar with examination conditions. The paper has certain elements removed and synoptic content was limited to that with a link to Unit 3 areas of study such as rates, equilibria, energetics, Group 4 chemistry and chemical tests. These changes make comparisons with previous exams much less valid. Despite this almost all candidates attempted almost all parts of every question. The few parts that were not attempted by some were different for each candidate although calculations were more likely to be omitted than questions requiring description or explanation. Time did not appear to be a problem with almost all candidates attempting the final part questions.

It was disappointing to see a number of candidates obtaining very low scores in Section A, where most of the marks were based on recall of work covered in this unit. The overall mean of 4.6 marks is significantly lower than in previous years. In Section B many areas of work elicited a range of acceptable responses, with many correct calculations and detailed explanations. Many questions which required factual recall were answered poorly, such as the colour of the precipitate formed upon addition of NaOH to Fe^{3+}(aq) or the origin of colour in transition metal complexes. Some candidates also lacked basic chemistry skills, such as writing balanced equations or ionic equations or writing electronic structures. Most candidates could gain marks for calculating a mean titre or reading the pH graph. Several questions had lower mean marks due to candidates appearing to be answering a different question, such as in Q9(d)(ii) and Q10(d). This may be due to carelessness in reading the questions or not understanding the requirements of the question.

Comments on individual questions/sections

SECTION A

Q.1 (a) This question assessed candidates recall of experimental observations and was very well answered. Most candidates were able to qualify the colour ‘yellow’ with an appropriate term such as ‘bright’ or ‘canary’.

(b) It was disappointing to see that many candidates did not understand the requirements of an ionic equation with answers including nitrate ions or potassium ions being seen frequently. Those candidates that understood the requirements of ionic equations did not always balance the equation or give the correct formula for lead(II) iodide.

Q.2 Almost half the candidates were able to give a correct formula here, although some candidates gave a 2+ charge or thought that there should be two water ligands in addition to the four chloride ligands.

Q.3 (a) Some candidates were able to give a correct rate equation, although a minority did not write an equation and simply stated '$k[N_2O_5]$'. Rate = $k[N_2O_5]$ was required.

(b) This was poorly answered. Many did not write an equation starting with one molecule of N_2O_5, and a significant number of those who did start the equation correctly did not include products that balanced the equation.

Q.4 Most candidates were able to recall the correct standard conditions, however few were able to explain the meaning of the electrode potential.

Q.5 This was well answered by stronger candidates. Many candidates who did not gain the mark were ones that incorrectly referred to the inert pair effect or just discussed one of the two elements rather than both or making a clear comparison.

Q.6 This question was answered correctly by most and has the highest facility factor of any question in the paper.

Q.7 Most candidates realised that the entropy of a liquid was much higher than that of a solid but a few could not give a reason for this in terms of disorder of degree of freedom.

SECTION B

Q.8 (a) Most candidates recalled the layer structure of graphite and the presence of weak van der Waals' forces. A few suggested the weak forces were within the layers or were unclear as to their location.

(b) (i) Most candidates gave the correct answer here. A small number did not realise that the atomisation was half the bond energy and gave 242 as their answer.

(ii) This question was answered well by stronger candidates. They could apply the ideas of Born-Haber cycles appropriately and most candidates who obtained an incorrect answer gained some credit for their working.

(iii) A minority of candidates realised that the entropy change would be negative due to the physical states of reactants and product, however fewer were able to use the impact of the exothermic reaction on the entropy of the surroundings to explain why the reaction was feasible. Some used Gibbs free energy as part of their argument and this was acceptable.

(c) Most candidates were able to identify some of the ions present in tachyhydrite and explain their decisions in terms of the observations given, but it was far more common to see Ca^{2+} identified than Mg^{2+}. Many were able to calculate the number of water molecules in the formula. Few were able to combine this information with the relative mass and the charges to give a correct overall formula.

Q.9 (a) Many candidates knew the meaning of the term transition element. Most seemed familiar with the electronic structure of the iron atom but few could write the correct electronic structure of the ion and it was common to see 4s electrons remaining and a few wrote 4d rather than 3d.

(b) This question was poorly answered, especially as it required only recall.

(c) Most answers showed an understanding of the structure of the ion, but several common errors were penalised. The most frequent of these were drawing the bonds from Fe to H rather than O and writing the formula of water as O_2H rather than OH_2.

(d) (i) Many candidates gave answers incorrectly based on the iron ions having different oxidation states in the two complexes. Other candidates gave an explanation of the origin of colour rather than explaining why the two ions have different colours.

(ii) This was poorly answered and few realised that the choice of frequency depended on the frequencies absorbed by both ions.

(iii) Most candidates gained marks on this question. A few lost marks for placing their charges outside the brackets representing concentration. A few others exchanged the reactants and products in the expression.

(iv) Most candidates gained some marks here, but few gained all four. Almost all gained a mark for calculating the concentration of H^+ ions. Some gained three marks for a value of approximately 195 which does not include the iron that is present in $[Fe(H_2O)_5(OH)]^{2+}$ at equilibrium.

(e) (i) Few candidates gained this mark. There was a significant minority that thought the precipitate would be green, although a wide spectrum of colours were suggested. A correct formula for iron(III) hydroxide was rarely seen.

(ii) Many candidates gained marks on this question. The most common errors were to discuss the water oxidising the Fe^{2+} rather than the oxygen.

(iii) This question was poorly answered. Many found it a challenge to link Le Chatelier's principle to the oxygen half-cell equilibrium and were penalised for this.

(f) (i) It was disappointing to see that a significant minority of candidates were unable to write a balanced equation using the information given in the question.

(ii) Most realised that this was due to the relative stability of the oxidation states, but a few gave vague answers such as 'carbon prefers to be in CO_2 rather than CO' and gained no credit.

Q.10 (a) Many identified both indicators, but a few were vague in their reasons and did not refer to the vertical region of the graph.

(b) Fewer than half of candidates gained both marks here which is disappointing for a question based on work that has been covered several times throughout the GCE and GCSE courses.

(c) This was a challenging question which distinguished between candidates aiming for the highest grades. Many candidates gained a mark for reading the pH at 10.0 cm^3. Few were able to use this to find K_a and hence to find the initial pH of the weak acid although it was common to see candidates gaining some marks for their method.

(d) Too many candidates did not answer the question set, with many simply defining a buffer. A wide range of uses were accepted, but fewer than half of candidates gained a mark here.

(e) Most candidates were able to calculate a temperature but some forgot to convert between J and kJ and so obtained an answer that was out by three orders of magnitude. Many could apply Le Chatelier's principle to the degree of dissociation.

Q.11 (a) (i) Almost all candidates calculated this correctly.

(ii) Many were able to calculate the concentration correctly. A significant number did not identify the 2:1 reaction ratio and gained an answer that was double the correct value.

(iii) This was poorly answered. The conversion between concentration in mol and g has often been a challenge for candidates.

(iv) A minority identified the correct concentration. Many knew that the volumes were too small and needed to be larger to reduce the percentage error but fewer understood the problem with using concentrations that were too low.

(b) (i) I. The orders of reaction with respect to both reactants were usually given correctly. Some working was needed to ensure that candidates did not simply guess, however any approach was allowed. Many candidates simply annotated the table which was perfectly acceptable.

II. Many candidates found this question challenging. Some attempted to calculate the value of *k* and apply it to experiment 4. Others realised that experiment 4 was the same as experiment 3 apart from the concentration of H^+ and applied this correctly.

(ii) The Arrhenius equation includes some of the most challenging mathematical work in the unit. Despite this, questions involving this equation are generally answered well. There were many ways to approach this question, with candidates able to compare calculated rates, the value of *k* or simply the exponential expression. All three were seen and given credit.

An error seen in some answers was a failure to convert kJ to J. This led to an answer of approximately 1, and it was disappointing to see that some candidates considered this to be a reasonable answer. The final answer was marked consequentially from the values calculated, so it was acceptable to state the rule was wrong if this was the conclusion from their calculations.

(c) (i) Many candidates gained this mark.

(ii) I. Many candidates gained some credit but few gained full marks. The calculation of moles from mass was performed well. Many gained marks on the gas calculation as well but some failed to change the volume to m^3 and the temperature to K. Few were able to give both their answers to appropriate numbers of significant figures.

II. This challenged candidates and few realised that the numbers of significant figures in both measurements were relevant.

III. Only the best candidates gained both marks here. Some realised that the hydrogen would have a much lower mass but few realised that it would have no effect on the volume of gas.

(iii) Most were able to suggest an appropriate pH but fewer were able to give reasons for this. Some candidates relied on the idea that a strong acid is stronger than a weak base so the salt will be acidic without any idea why.

Summary of key points

- Recall of factual content in AO1 questions was poor and key knowledge such as the meanings of terms, experimental observations, chemical tests and equations need to be learnt thoroughly. The factual content is the basis for many recall questions as well as questions requiring analysis or calculations.
- Writing balanced equations of different types is a fundamental skill in chemistry and in many cases candidates could not do this. This led to problems in Q3(b) and Q9(f). Writing ionic equations also challenged some candidates in Q1(b).
- Calculations requiring changes of units, such as from J to kJ, cm^3 to dm^3 to m^3 and K to °C, are common in this exam. Candidates should familiarise themselves with questions where the units are always interconverted, such as enthalpy and entropy or the ideal gas equation, and ones which may require interconversion such as the use of atm and °C. In this paper these appeared in Q10(e), Q11(a), Q11(b)(ii) and Q11(c)(ii)I where some candidates lost numerous marks.
- Questions that relied on recall and understanding of practical methods were more poorly answered than ones based solely on the theory studied. This may reflect a reduction in practical work due to recent restrictions. This was seen in Q10, Q11(a) and Q11(c). It is important that candidates appreciate why they carry out each step in their practical work e.g. which reactant in is excess and why, why certain concentrations are used rather than higher/lower ones and why certain temperatures are used.

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UNIT 4 – ORGANIC CHEMISTRY AND ANALYSIS

General Comments

The paper was generally accessible to all candidates and offered an appropriate range of all the Unit 4 topics and levels of difficulty. Consequently, those questions designed for all to attempt proved successful and the more challenging and demanding tasks clearly acted as discriminating aspects of the paper. Moreover, there were many exceptional candidates and excellent responses to the more difficult and thought-provoking questions.

The paper overall offered all candidates the opportunity to highlight exactly what they could do e.g. the mathematical tasks spanned the entire range of calculations from analysing a basic chromatogram to complex molar analysis.

Comments on individual questions/sections

Section A proved to be, as expected, the most accessible part of the paper, with all candidates able to attempt the majority of questions with confidence.

Q.1 & Q.2 Most students scored marks here.

Q.3-Q.5 Most candidates attempted these questions but many responses were only partially correct and included careless errors:

- many drew the aromatic carboxylic acid functional group but left out either the Cl group at position 4 or forgot to balance the equation by including HCl in Q3
- whilst many could draw a correct isomer, most contained either two or four equivalent hydrogens and not the desired three environments in Q4
- many drew the correct structure but too many got the NH_2 incorrect, replacing with a nitro- or diazonium group in Q5

Q.6 (a) Answers offered a range of the various combinations of mechanisms from electrophilic substitution to the correct nucleophilic addition.

(b) This was a lot more successful with many good answers and well-drawn mirror images.

Q.7 (a) (i) Most managed to draw the structure for butanoic acid.

(ii) Most made good attempts the hydroxy carbonyl isomer.

(b) This proved to be the first real stumbling block. Contradictory explanations were sometimes seen e.g. ‘the structure gives one peak because all the peaks are equivalent’ followed by ‘and this peak is split into a triplet’. This gained no credit. There were not many good answers here.

Section B was more testing for many candidates and very few fully came to terms with the demands of the next five questions. However, most provided very valiant attempts at each question and very few were regularly not attempted.

Q.8 Whilst most of parts (a) & (b) were well-attempted, the task to find the percentage by mass of oxygen proved difficult for many candidates who could not accurately find the molar mass of the two compounds. The rest of the question was answered quite well with reaction catalysts, conditions and IR all being tackled successfully.

Candidates struggled to answer question (c)(i) fully. Many managed to explain why the polymerisation was addition – referring to the C=C bond breaking or the lack of a second product formed – but most either left it there or struggled to explain why the polymer wasn't a polyester. The molar mass of the polymer in part (ii) was calculated by most.

Q.9 Part (a) included mostly AO1 questions requiring recall of facts such as organic reaction reagents/conditions/catalysts along with common qualitative tests. This was poorly answered. Part (iii) was especially disappointing with most candidates concentrating on poly-nitration rather than comparing the closeness of the boiling points.

The equation was balanced quite well in part (b).

The mechanism in part (c) was not done well and most candidates showed no real understanding of the use of arrows, with many quite obviously guessing where they should go. Most gained the second mark for showing all three products.

Part (d) involved three tasks. The calculation was quite well done and the most common error was to forget to take into account the 86% yield. Most could not define a radical in part (ii) and many stated that a radical has a 'lone pair' rather than an 'unpaired electron'. Many had no difficulty giving an example of a radical in part (iii).

Part (e) proved a problem for most. Whilst the majority identified the test results, they could not apply that observation to describe how they would know when the reaction was finished. Many said that 'a white precipitate is produced' but very few added that no more of this would form when the reaction was just complete.

Answers to part (f) were also mixed. Parts (i) & (ii) saw many score good marks but few two- mark answers were seen for part (iii). Many ignored the lone pair on the nitrogen and discussed the delocalisation.

Q.10 The QER question in part (a) was clearly a discriminator but nearly every candidate attempted to find the structure. Marks across the full range were seen with more scoring 5or 6 marks than 0 or 1. Almost all candidates included something appropriate in their answers and many brought all their points together very concisely and effectively to identify compound **G**.

A variety of responses were seen in part (b). Those that kept their answers simple by treating the calculation as a ratio sum usually scored two marks. Those that tried to include Planck's constant or the speed of light generally lost their way and gained no marks.

Part (c) was poorly answered. Part (i) showed that most students did not recall this reaction with most giving the structure of the acid rather than the sodium salt. Many recognised that the C—N bond in the aromatic amine was strengthened by delocalisation but only a few identified the attacking species as a nucleophile. Part (ii) proved more difficult than expected. Many of those who gave the correct organic product then failed to balance the equation.

Q.11 Part (a)(i) was very poorly answered. Candidates just did not get to grips with this very basic question. Most didn't realise the significance of the start line being at 1cm. The rest of part (a) was better answered as was part (b).

Part (c) proved more demanding. Those that did manage to identify that three peaks would be seen failed to explain their reasoning adequately. Those that did score two marks made their explanations simple by labelling the equivalent carbon atoms in the structure given.

Q.12 Part (a) was very well answered but marks were lost needlessly in part (ii) when candidates drew out the structure rather than providing the molecular formula of $C_{10}H_{10}O_3$. Many candidates completely missed the question requiring a chiral centre to be identified on the structure in part (iii)II.

The final part of the paper was not well answered. Part (b)(i) again saw a variety of answers and the usual range of combinations from nucleophilic substitution to the correct electrophilic addition. Part (ii) was the weakest of the calculations on the paper with many candidates focusing more on the iodine than the palm oil and consequently scoring no marks. Many managed to place a 3 in front of the NaOH in the equation but the sodium salt proved too difficult for most and few scored both marks.

Part (iv) was quite well answered but many lost marks by giving propane-1,2,3-ol rather than propane-1,2,3-triol.

Summary of key points

This was a fair paper but many candidates missed the chance to score straightforward marks by not being able to recall basic facts such as mechanism names, reaction conditions and reagents. The calculations were varied and overall proved to be discriminators with only the strongest candidates accessing the harder questions.

The best candidates gave exceptional responses to the challenging questions such as Q10(a), Q10(c), Q11(c) and Q12(b).

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UNIT 5 – EXPERIMENTAL TASK

General Comments

The Experimental Task allowed the opportunity for all candidates to score the majority of the marks for data collection, recording and processing. The task included an enthalpy determination and a range of qualitative tests. The analysis that followed was generally straightforward and most scored marks in excess of 24 out of 30.

Comments on individual questions/sections

Two marks were awarded by teachers upon observation of the candidates carrying out the work. Almost all were awarded both marks. Centres are reminded that these marks should be added to the front cover of the candidate scripts immediately after they complete the assessment.

Carrying out the two enthalpy experiments proved straightforward for most candidates. Results were usually recorded in appropriately labelled tables. Marks were lost where candidates clearly mixed up their solids and either recorded two temperature increases or two temperature decreases and where temperatures were recorded for only four minutes rather than seven.

Examiners marked the observations flexibly in the qualitative tests section taking into account the following points:

- flame tests were not always clear
- the addition of sodium sulfate gave varied results depending on the original amount of solid added (no mark was awarded for this test but the observation recorded was used in the analysis)

Marks lost here usually resulted from vague observations or poor terminology e.g. white solution forms.

Graphs were well drawn by most candidates with appropriate scales, labelled axes and correctly plotted points. However, many did drop a mark on at least one graph for not extrapolating their graph back to 180 seconds (the time of solid addition). Other marks were lost for inaccurately reading the scale and for recording incorrect temperature changes.

Most candidates scored well on parts (ii) & (iii) and many scored all eight marks in the calculation of the three enthalpy values. Marks were lost for the following:

- incorrect molar calculations
- using the mass of solid rather than the mass of solution
- needless conversion to Kelvin
- using the incorrect sign resulting in an exothermic answer for an endothermic reaction or vice versa
- not dividing by 1000 to convert J to kJ

Marks were dropped in part (iii) for an incorrect overall enthalpy change resulting from incorrect signs and/or forgetting to double the enthalpy change for potassium hydrogencarbonate.

Part (iv) proved to be the real discriminating question with a range of marks from the very rarely seen 0 through to the full 6 marks. Candidates were awarded a mark for any correct inference from their qualitative observations, even if some were contradictory. However, many lost marks as they merely repeated their observation results without any inference.

Summary of key points

Graphs are plotted in enthalpy change practicals such as these in order to extrapolate back to the time of mixing to estimate the maximum temperature change.

In qualitative analysis candidates must clearly state what inferences or conclusions they draw from each test.

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UNIT 5 – PRACTICAL METHODS AND ANALYSIS TASK

General Comments

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.

Good attempts were made at most of the calculation questions, where many candidates set out their answers sufficiently clearly to be able to see what was being calculated at each stage, allowing partial credit to be given when final answers were incorrect.

There was no indication that candidates had a problem completing the paper in the time allowed. When questions were left blank it usually appeared to be as a result of lack of knowledge and understanding rather than time constraints.

Comments on individual questions/sections

Q.1 (a) Most candidates gained some marks here, but few gained all three marks. The weaker candidates did not give the correct observation for the addition of compound W to water. A significant minority gave the observation as 'yellow solution formed'. Very few candidates went on to correctly describe the observation on the dropwise addition of excess aqueous NaOH to a solution of compound W. However, most candidates were able to correctly identify that the inorganic salt contained the bromide ion. No credit was given for 'bromine ion'.

(b) It was disappointing to see that a significant minority of candidates were unable to write a balanced ionic equation for the formation of the cream precipitate of AgBr.

Q.2 (a) This question required the candidates to distinguish between two isomers using reagents of their choice and detailing the observations for the positive test. It clearly differentiated between those that had thoroughly revised the organic functional group tests and those that had not. It was surprising to see that some A2 candidates were unable to score any marks for this question.

(i) Although many candidates knew that the iodoform test gave a positive result for compound C but not for compound F, some of them gave 'iodoform' as a reagent and gained no credit.

(ii) This question was answered correctly by most candidates.

(b) This question was poorly answered, with weaker candidates attempting to calculate the percentage yield without finding any M_r values or the number of moles of reactant. Far too many simply divided the mass of reactant by the mass of product and multiplied by 100.

(c) This question was poorly answered, with many candidates giving the displayed formula of propan-2-ol as the intermediate.

(d) Many candidates gained one mark for this question. The most common error was incorrectly calculating the number of moles of magnesium as equivalent to the number of moles of compound A. Some candidates were also unable to convert the calculated mass of magnesium into the required length of magnesium ribbon.

Q.3 (a) This question was poorly answered with hardly any candidates referring to the purity of the potassium manganate(VII) solution or that the manganate(VII) could have absorbed moisture from the air. An answer of 'need to know its concentration' was not sufficient to gain the mark.

(b) Most candidates gained a mark on this question referring to the colour change seen at the end point. An answer of 'it is self-indicating' was not awarded the mark.

(c) This question was poorly answered. It relied on the understanding of practical methods and why using just one iron tablet in the preparation of the iron solution would give a titre volume of less than 5 cm^3 and hence a high percentage error.

(d) (i) Almost all candidates gave the correct equation for the redox reaction.

(ii) Most were able to calculate correctly the number of moles of manganate(VII) in the mean titre. However very few candidates were then able to calculate the number of moles of iron present in just one iron tablet. Many multiplied the number of moles of manganate(VII) by 5 for the mole ratio given in part (i) but did not then multiply by a factor of 10 to change from 25 cm^3 of solution used in the titration to 250 cm^3 of solution in the volumetric flask. The final error was to not divide by the number of tablets used.

(iii) Only the best candidates gained both marks here. The first mark required the candidate to calculate the answer in mg, with a surprising number of candidates unable to convert the calculated mass in g to mg. The second mark was only awarded to a very small minority of candidates who suggested the prior oxidation of Fe^{2+} to Fe^{3+}.

Q.4 Whilst this question and the calculation of K_c for the hydrolysis of ethyl ethanoate was challenging, the majority of candidates who attempted it scored at least 2 marks. Since the calculation of K_c in (c)(iv) followed a series of structured calculations to determine the initial composition of reactants and the equilibrium composition of components, the most able candidates scored full or nearly full marks.

(a) (i) Most were able to calculate the number of moles of NaOH correctly but only a few were then able to calculate the total number of moles of acid present in the 60 cm^3 of solution at equilibrium.

(ii) Many candidates calculated the number of moles of concentrated HCl added as a catalyst, but very few then went on to subtract this value from the total number of moles of acid calculated in part (i).

(b) Most candidates were able to use the data on page 10 together with the given mass/volume/density expression to gain one mark for calculating the mass of 4 cm^3 of HCl solution. Many were also able to calculate, based on the number of moles of concentrated HCl calculated in part (a)(ii), the mass of HCl in 4.00 cm^3 of solution. However, only a very small minority of candidates were then able to calculate the mass of water present in 4 cm^3 of the concentrated HCl solution

(c) (i) This 2 mark calculation of the initial number of moles of the ester was well answered by the majority of candidates

(ii) Many candidates gained both marks under 'error carried forward' rules when they had made an error in parts (a) and (c)(i).

(iii) Where the moles of each component at equilibrium were calculated in part (c)(i), the vast majority of candidates were able to correctly calculate the value of the equilibrium constant.

Summary of key points

- As noted in a previous report, more marks are lost for shortcomings in basic recall than in dealing with data given in new situations. Recall of organic functional group tests and the linked observations is essential. Similarly, candidates should be able to recall how to test for the inorganic ions listed in the specification, describe the linked observations and be able to write ionic equations for the reactions taking place.

- Too many candidates lost a mark in the quantitative analysis question 4(a)(i) by not scaling up correctly from 10 cm^3 to 60 cm^3 and similarly in question 3(d)(ii) in calculating the number of moles of iron in one iron tablet. Candidates are again advised to read questions carefully.

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