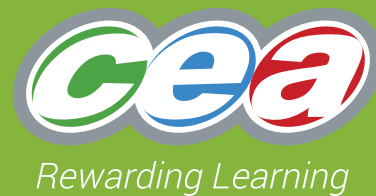


GCE



Chief Examiner's Report
Chemistry

Summer Series 2022



Foreword

This booklet outlines the performance of candidates in all aspects of this specification for the Summer 2022 series.

CCEA hopes that the Chief Examiner's and/or Principal Moderator's report(s) will be viewed as a helpful and constructive medium to further support teachers and the learning process.

This booklet forms part of the suite of support materials for the specification. Further materials are available from the specification's microsite on our website at www.ccea.org.uk.

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GCE CHEMISTRY

Chief Examiner's Report

Subject Overview

- Most candidates followed the new instructions for answering multiple-choice questions. Candidates should be encouraged to write the answer clearly as A, B, C or D on the answer line. This year some candidates circled the answer or wrote the actual answer on the very short line.
- Definitions from the clarification of terms document are expected to contain all the key elements given. Colour changes and observations and descriptions of practical work should also follow the support documents.
- Practical chemistry will continue to be assessed in the theory papers as well as the practical papers and candidates are expected to be able to apply their knowledge to the context of the chemistry involved.
- Systematic names of inorganic compounds were poorly answered in AS and A2.
- From 2023, it will be expected that positive enthalpy changes, positive entropy changes, positive free energy changes, positive electrode potentials and positive emf values will have the positive sign.
- Intermolecular forces questions occur throughout the suite of papers and candidates most often lose marks for not explaining that these are between molecules. Common incorrect answers of the type "hydrogen fluoride contains hydrogen bonds" are not credited.
- Candidates should spell chemical names correctly. A wide variation in spelling of phenolphthalein, terephthalate and even simpler names was evident throughout the suite of papers.
- Connectivity was and will continue to be penalised in all structures if candidates connect the incorrect atom in a group to a covalent (or co-ordinate) bond.
- Substituent groups of more than one atom in the middle of a condensed structural formula must be in a bracket.
- In future years, space for candidates working out during calculations (and not lines) will have an answer line at the bottom of the space. Units will be expected, where appropriate, unless provided at the end of the answer line.
- Any errors including commas and hyphens in organic nomenclature are penalised.
- Candidates should be careful not to confuse oxidation states and charges. These types of errors are penalised throughout AS and A2.
- Candidates are now guided in calculations as to the number of decimal places or significant figures if this is a required element of question. Appropriate number of significant figures means that candidates choose the number of significant figures for the final answer based on the data given in the question.
- Candidates should try to limit their answer to the space provided but if they have to write elsewhere this should be indicated clearly in the main answer space. If they use a supplementary answer booklet, candidates should ensure that the question number and part are clearly and correctly indicated.

Assessment Unit AS 1 Basic Concepts in Physical and Inorganic Chemistry

Summary points

- Few candidates gave correct systematic names for NaBrO and NaBrO_3 with oxidation states missing or incorrect.
- Explanations of change in boiling points of hydrogen halides were often confused in terms of the intermolecular forces or answered incorrectly in terms of electronegativity and/or ionisation energies.
- Important detail was often missing in definitions of electronegativity and relative atomic mass.

Multiple Choice Questions 1 – 10

The multiple-choice questions were well answered with questions 5, 9 and 10 being the ones most frequently answered incorrectly.

- Q11** In Part (a)(i) most candidates were able to explain what is meant by a disproportionation reaction and in this question “oxidation and reduction [1] of the same element [1]” was all that was expected as the term reaction was used in the question. Answers involving “species” and not “element” were not credited for the second mark. The equation in Part (a)(ii) was relatively well answered but CuO was a common mistake for copper(I) oxide. Most candidates gave flame test and blue-green flame in Part (b) but some described the flame test and if enough detail was present this was credited.
- Q12** In Part (a) many knew the colours of iodine in water and iodine and hexane. The solubility mark was sometimes lost if candidates stated that iodine was insoluble in water. Partially insoluble was credited if linked with more soluble in hexane. For Part (b) a significant number of candidates discussed electronegativity and ionisation energies with no mention of intermolecular forces. For those candidates who did discuss the boiling point pattern in terms of intermolecular forces, the most often missed mark was “between molecules” for hydrogen bonding in hydrogen fluoride. In Part (c)(i) very few candidates were awarded any marks here. It was rare to see an answer with oxidation states of any kind. The conditions and equations in Part (c)(ii) were relatively well answered, the second equation proving more challenging than the first. In Part (c)(iii) most candidates gained marks for the test for bromide ions however, “solution” was often missing for silver nitrate but cream precipitate was still credited. In Part (d)(i) many candidates scored well with varied advantages for chlorine and ozone in water treatment. Most common answer as per the mark scheme. In Part (d)(ii) most candidates scored well here too but damp and paper were sometimes missed for the damp universal indicator paper/damp litmus paper.
- Q13** In Part (a)(i) the equation representing the first ionisation energy of lithium was well answered with some not giving state symbols. The quality of written communication question in Part (a)(ii) gained most candidates some marks. Most were able to explain the general trend. However, some details of the exceptions were not explained fully enough in terms of the stability of the filled 2s subshell for beryllium and half-filled 2p subshell for nitrogen. Part (b)(i) and (ii) focussed on electronegativity and many candidates correctly recalled the definition and some were able to explain the trend in terms of the nuclear charge increasing and the attraction for the bonding electrons increasing. In Part (c), for Part (i) many candidates correctly described the

large difference in electronegativity. In Part (c)(ii) the dot and cross diagram question for OF₂ was well answered but a few did attempt an ionic style dot and cross which lost all the marks. The polarity of the O–F bond in Part (c)(iii) was mostly correct but some candidates' attempts at a "δ" were surprisingly poor with many looking like other letters. The shape in Part (c)(iv) was mostly correct with some giving "linear" which was not credited. Bent and v-shaped were the only credited answers.

- Q14** In Part (a)(i), the definition of relative formula mass was poorly answered in terms of the first part but a good number of candidates were able to gain a mark for relative to a twelfth of the mass of an atom of carbon-12. Formula unit was not seen often in the first part of the definition. The calculation of molarity in Part (a)(ii) was poorly answered in terms of significant figures. Despite the question stating 2 significant figures some answered to 3 or 1. A significant number of candidates did not multiply by 10 to convert to 1 dm³ and units were sometimes incorrect. Candidates can lose two marks simply by not answering to the correct number of significant numbers (or decimal places) and not giving the appropriate unit. In Part (b), the dot and cross diagram for sodium chloride provided many correct answers but some candidates did provide a covalent diagram in addition to an ionic one which lost both marks. In Part (c)(i) the equation was often correct and 1 mark was awarded for the equation forming Na₂SO₄. The test for hydrogen chloride gas was well answered in Part (c)(ii).
- Q15** In Part(a)(i) most candidates scored well but some lost all the marks available for an answer involving van der Waals' forces. A correct description of metallic bonding was allowed in place of the term. Almost all candidates scored 2 marks for the explanation as to why thallium conducts electricity in Part (a)(ii). Candidates also performed well in Part (c) with most gaining a mark for "outer electron in p subshell" in Part (c)(i). The period and group were almost always correct in Part (c)(ii) and most were able to write the electronic configuration of the ions in Part (c)(iii). The incorrect d⁸ s² configuration was sometimes seen for the Tl³⁺ ion. A few candidates confused the symbol for thallium with the symbol for titanium in Part (c) and this was not credited. The calculation of the loss in mass in Part(d) was well answered. Some calculated the mass of Tl₂O and subtracted and if the answer was given to 3 significant figures with units, candidates achieved all the marks. Common errors were incorrect RFMs and again not giving the numerical answer to the number of significant figures asked for in the question.
- Q16** The definitions of hydrated and weak acid in Part (a) and Part (b) were well answered. Very few candidates lost marks in Part (a) and a few did not include "in water/in solution" in Part (b) and this was not credited. Many different spellings of phenolphthalein were seen in Part (c)(i). Also, a surprising number of candidates did give methyl orange. Colours were marked accordingly based on the alkali being added to the acid. The calculations in Part (c)(ii) and Part (iii) were often correct but decimal places were sometimes incorrect in Part (c)(i) and the multiplication by 10 step was sometimes missed. Errors were carried forward into Part (c)(iii) and answers credited if the method was correct.

Assessment Unit AS 2 Further Physical and Inorganic Chemistry and Introduction to Organic Chemistry

Summary points

- As in previous years, it was disappointing to see many candidates giving incorrect formulae for Group II compounds such as strontium hydroxide and strontium nitrate. The formula of nitric acid was not well known and a knowledge of simple reactions such as that of a reactive metal with water or a metal oxide with an acid was lacking for many candidates.
- The drawing of organic structures often left a lot to be desired. In stable structures, carbon atoms should be involved in four bonds, oxygen atoms two and hydrogen atoms only one. Except in skeletal representations, hydrogen atoms should not be ignored. The connectivity of side chains, such as the methyl group, should show clearly that there is a carbon to carbon bond between the main chain and the branch.
- The highest scoring candidates scored very well in the questions which required the recall of definitions. At the other end of the scale, many of these marks were lost.
- Except in the highest scoring candidates, knowledge of the nucleophilic substitution mechanisms for primary and tertiary halogenoalkanes was poor.

Multiple Choice Questions 1 – 10

The multiple-choice questions were well answered with Questions 5 and 10 proving to be the most challenging and Questions 3 and 4 proving to be the least challenging.

- Q11** Candidates scored well in this question. However, it was surprising to see chloromethane appearing so frequently in Part (e). The question was looking for “one other carbon-containing product”.
- Q12** It was disappointing to see that many candidates lost the one mark in Part (a) since they gave a less than perfect definition for what was considered to be a very simple concept. It was much more encouraging to see so many candidates scoring full marks in Part (b)(i) and (b)(ii). For those candidates who got the correct molecular formula, the structure of butanoic acid in Part (b)(iii) was very common. A second structure, in Part (b)(iii), with two functional groups proved to be very challenging. For those candidates who did not obtain the correct molecular formula, marks could still be obtained by carrying errors forward but it was important to give a realistic structure which matched the molecular formula. There were many examples of very poor practice when drawing organic structures, for example, carbon atoms which were involved in only three bonds.
- Q13** Most candidates scored the mark for Part (a). Many lost one of the marks in Part (b)(i) by leaving out an important detail such as “lone pair” in the definition. The polarity of the bond in Part (b)(ii) was correct in most cases but application of knowledge for the second mark proved too much for most. Candidates were expected to explain why the hydroxide ion is a nucleophile and comment on the partial positive charge on the carbon in the C–Br bond. In Part (b)(iii) and Part (c), knowledge of the two possible nucleophilic substitution mechanisms and the reason why primary halogenoalkanes and tertiary halogenoalkanes proceed via different routes was not evident in many scripts. Some attempts at drawing the mechanism were very disappointing. Mistakes in drawing the appropriate organic structures were evident. Covalent bonds between sodium and oxygen in sodium hydroxide were often shown. Curly arrows were often not “curly” and didn’t start or end in the right positions. However, there were some excellent answers.

- Q14** Answers in Part (a) were often disappointing, particularly in Part (a)(ii). Many candidates, even some of the highest scoring, did not get the mark for Part (b). Many suggested that it was because “oxygen is an element”. There were some excellent answers to Part (b) but some lost out by referring to oxygen as a compound. Many candidates scored three marks in Part (c) and lost the fourth mark since they did not divide by two. There were many excellent answers for Part (d) and it was clear that the concept of kinetic stability was well understood.
- Q15** The equilibrium topic was well known and knowledge was applied appropriately by many candidates. The vast majority of candidates gave a good explanation of the term in Part (a). In Part (b) candidates should be encouraged to begin these expressions with “ $K_c =$ ”. Most candidates indicated that, in this case, K_c has no units. The significance of a small value of K_c was not understood by many. It was very encouraging to see so many excellent answers to Part (c) and Part (d). However, it should be stressed to candidates that they need to answer the question. In both cases it was essential to comment on the yield of nitrogen(II) oxide.
- Q16** There were many excellent answers in Part (a)(i). When marks were lost it was often due to a missing subshell or the use of subscripts. The answers to Part (a)(ii) were often disappointing. Many candidates did not put emphasis on the outer electrons. Quite a few wanted to incorporate the concept of van der Waals’ forces in their explanations. The answers to Part (b) and Part (c) showed a lack of some very basic knowledge and the ability to apply this knowledge. The formula of nitric acid was not well known. The formulae of the strontium containing products proved to be problematic for many and the second product was often incorrect. Knowledge of the trends in the solubility of the Group II hydroxides and sulfates was not evident and the application of this knowledge in Part (d) proved to be very discriminating between the highest scoring candidates and the rest.
- Q17** Many candidates scored the mark for Part (a). The answers to Part (b) were of a high standard and most candidates seemed to understand skeletal representations. The last row in the table, for the fifth mark, did prove too much for most. Part (c) proved to be very challenging in terms of the concepts involved and in terms of the written communication. There were some excellent answers which scored full marks. Many candidates described the methyl group as a “molecule” or as a “functional group”. Many candidates described atoms or groups which are attached to the same carbon in the C=C as being “on the same side” of the C=C which in this context could be interpreted as “not diagonally opposite”. There was considerable generosity in terms of how priorities are assigned but it was clear that, for many, it was not well understood.
- Q18** The concept of intermolecular forces is a very important theme throughout AS and A2. In Part (a)(i), candidates needed to give a very clear indication that the van der Waals’ forces and the hydrogen bonding are between neighbouring molecules. This was often missing. Candidates should be advised that statements such as “propan-2-ol has hydrogen bonding” should include “between molecules” or “between neighbouring molecules”. The emphasis in Part (a)(ii) was on the oxygen and the hydrogen that are directly involved in the hydrogen bonding interaction. The oxygen should have two lone pairs and a partial negative charge. The hydrogen should be bonded to an oxygen in a neighbouring molecule, have a partial positive charge and the hydrogen bond should be between the hydrogen and the lone pair. The interaction is normally represented using some form of dashed line. In this case the interaction could have been between the oxygen in propan-2-ol and one of the hydrogens in a water molecule or between the oxygen in a water molecule and the –OH hydrogen in the alcohol. There were some issues with incorrect organic structures. HO_2 also made a few appearances. The answers to Part (b) were, in general, excellent. The oxidation of secondary alcohols was very well understood. Candidates should refer to “peaks” when describing the differences between spectra rather than the presence or absence of certain “bonds”.

Assessment Unit AS3 Basic Practical Chemistry Booklet A

Summary points

- Some candidates referred to the formation of a brown solution of iodine as red or red/brown.
- Many candidates ignored the instruction to give the values in their table to 1 decimal place and to give temperature values to the nearest whole number.
- Some candidates did not use the formula stated to calculate temperature change and as a result ended up with negative values for temperature change.

Q1 Question 1 was generally well answered by most candidates and very few misinterpreted the questions. In Part (a) the vast majority of students correctly described the flame colour as pink. Part (b) presented candidates with more difficulties than any other in Question 1. There were five acceptable responses for observations and most students were able to achieve at least one mark. For Part (c)(i) the colour of precipitate described did not always correspond to the observation expected with concentrated ammonia solution, although these two marks were treated independently and candidates could gain credit for 'precipitate remains' despite an incorrect colour of precipitate being initially stated. In Part (c)(ii) candidates were asked to describe the colour of a solution of iodine. Quite a few candidates incorrectly referred to the colour as being 'red' or red-brown'. This was also the case in Part (d) although the majority of students gained credit for 'effervescence' in Part (d). Most students were awarded a mark for Part (e)(i) although this mark was negated if the candidate referred to a blue-black precipitate. In Part (e)(ii) most candidates achieved at least 1 mark for the identification of two layers, though some did not correctly identify colours.

Q2 Question 2 allowed for more discrimination between candidates but overall was well answered by the majority of candidates. In Part (a) the table was well completed by many. Mistakes included failure to give values to the correct number of decimal places as instructed and inclusion of units in the body of the table. The graph in Part (b) was well drawn by the majority of candidates. A small number of candidates used negative values for temperature change on the y-axis and a small number put temperature change along the x-axis. In Part (c) most marks were lost by taking values from the table rather than the graph. A few also read incorrectly from the graph. A surprising number of candidates were unable to calculate the gradient of the graph using the concept of rise/run. Part (d) was generally well answered.

Many of the marks lost on this paper were as a result of candidates not reading the questions correctly.

Assessment Unit AS3 Basic Practical Chemistry Booklet B

Summary points

- Calculation questions were well attempted by most students and were clearly laid out enabling partial credit to be awarded.
 - In most cases where credit was not awarded it was for candidates not having knowledge of facts, in particular in the recall of definitions from the clarification of terms document.
 - In Question 4 candidates were frequently penalised for poor connectivity when drawing organic structures/ writing equations, or for naming organic compounds using nomenclature rules.
- Q1** For Part (a) and Part (c)(ii), these calculation questions were well attempted by most candidates. Some did not read questions carefully enough and did not give answer to the appropriate number of decimal places. Most showed working out so it was possible to give partial credit even if correct answer was not given. The rest of Question 1 was generally well attempted. In Part (c)(ii) some candidates did not state the term 'flame test' but if a clear description of a flame test was given, this mark was awarded.
- Q2** Question 2 was well answered. In Part (a) the observations with solid phosphorous pentachloride posed most problems but most students achieved some credit. In Part (c) most candidates achieved at least one mark for the ionic equation, however, marks were not awarded if electrons were included.
- Q3** The calculation questions part (a) and part (b)(iii) were well answered by most candidates. Again, most laid out the calculations well and achieved some credit. In Part (b)(ii) many students did not refer to a weak acid and therefore did not achieve credit. In Part (c) most who correctly answered Part (b)(iii) correctly were able to deduce structural formula.
- Q4** Question 4 was more discriminating. Part (a)(i) was generally well answered. In Part (b)(i) many did not know the definition and left out the words "by reaction". Part (b)(iii) was misinterpreted by many students and the response 'white precipitate' given, as the question had not been read thoroughly. In Part (b)(iv) and Part (b)(v) many referred to time rather than rate and did not gain credit as this was not answering the question. All parts of Part (c) were reasonably well answered. Again, some had not learned the definition for reflux accurately. Most students were able to achieve some credit for the calculation in Part (c)(vi) as steps were clearly laid out by most candidates.

Assessment Unit A21 Further Physical and Organic Chemistry

Summary points

- Practical techniques were not well known or understood. Candidates had difficulty applying knowledge to the context of practical questions.
- Material new to the specification, such as the mechanism for aromatic alkylation and transesterification were generally well known.
- In general, calculations were answered either very well or very poorly.

Multiple Choice Questions 1 – 10

The multiple-choice questions were generally well answered. Questions 6 and 10 were the best answered. Candidates were most challenged by Questions 3, 5, 7 and 8, all of which contained a calculation.

- Q11** Most candidates scored both marks in Part (a)(i) with the vast majority giving an answer to the correct number of significant figures. Some candidates had difficulty interpreting the rate data given in order to complete the table in Part (a)(ii). The description of the colorimetry method was very poor by many candidates in Part (b). Many simply had little knowledge of the procedure whereas others did not apply their knowledge, failing to mention the change in iodine concentration and how it relates to absorbance. Some candidates incorrectly referred to iodide concentration. In Part (c), many candidates were able to explain why step 1 was the rate determining step in Part (i), although only the most able candidates were able to suggest why steps 2 and 4 were faster in Part (ii). Fewer than ten percent of candidates were able to give the correct systematic name in Part (iii) which was surprising; some candidates named the ion as iodate but not give the oxidation state.
- Q12** Most candidates scored highly in Part (a). A small number of candidates did not give their answer to 3 significant figures or state the units for the free energy change in Part (iii). The definition for lattice enthalpy was well known in Part (b)(i). The most common error for the calculation of lattice enthalpy in Part (b)(ii) was not to divide the value for the change $\text{O}_2(\text{g}) \rightarrow 2\text{O}(\text{g})$ by 2. This was seen in a significant number of scripts. Whilst most candidates wrote the correct equation for the second electron affinity of oxygen, only the most able candidates were able to correctly explain why it is endothermic. In Part (c), many candidates were not awarded both marks in Part (i) as they referred to the enthalpy of hydration of magnesium rather than the enthalpy of hydration of magnesium ions. Less than half of the candidates correctly suggested why there was no value for the enthalpy of solution of magnesium oxide in a data book.
- Q13** Most candidates wrote the correct equation for the reaction of bromine with benzene in Part (a)(i) but had more difficulty with the equation involving propene. The table was generally well answered in Part (a)(ii) though a number of candidates named the bromine/propene product as 1,2-bromopropane rather than 1,2-dibromopropane. Part (a)(iii) was not well answered, only the most able candidates correctly linked the stability of benzene to the delocalised system of electrons. A variety of alternative responses were accepted however most candidates only scored one mark. The reagent and catalyst in Part (b)(i) were well known and the mechanism in Part (b)(ii) was well answered. Some candidates had difficulty with curly arrows though the mechanism was better answered compared to previous series. Only the most able candidates correctly identified the mechanism as radical substitution in Part (b)(iii).

Many candidates were able to identify the organic impurity in Part (b)(v) and a variety of responses were accepted for the name. A small number of candidates incorrectly identified the impurity as mercury as its relative atomic mass is 201. This was despite the question stem indicating the impurity was organic. The equation in Part (c)(i) was well known and most candidates correctly described use of melting point and comparison of data in Part (c)(ii).

- Q14** Most candidates correctly identified the alcohol isomers in Part (a)(i). The definition of optically active was well known in Part (a)(ii) and candidates generally identified the correct optically active alcohols in Part (a)(ii) although were penalised for including additional, incorrect answers. In Part (a)(iv), credit was given if candidates named the optically active oxidation product as some candidates misinterpreted the question. Many candidates correctly wrote the esterification equation in Part (b)(i) though only scored one mark as they did not include a reversible arrow. The QWC question in Part (b)(ii) was poorly answered. As with Part (b), the general procedure was not known well enough by a significant number of candidates or candidates were unable to apply their knowledge of the general procedure to the context of the question. Many candidates answered the question as if the ester was a solid rather than a liquid which was not credited. The word solution was often omitted when reference was made to use of sodium carbonate and many candidates did not make reference to the use of a stopper when using the separating funnel, both of which have been noted in previous series. Most candidates correctly drew the structure of the triglyceride in Part (c)(i) however the explanation of why it is a solid was poor by most candidates. Many candidates made reference to the triglyceride being saturated which was not credited. Whilst some candidates gave van der Waals' forces, a significant number did not specify that they acted between molecules. The definition of transesterification was well known in Part (c)(ii). Some candidates had difficulty with the equation for the formation of biodiesel and others used methanol instead of ethanol as the question asked.
- Q15** As with Part (c)(i), many candidates poorly answered Part (a)(i) and did not specify that hydrogen bonds act between molecules. The calculation was well answered in Part (a)(ii). Many candidates did not understand the question in Part (b)(i) and were unable to write an expression for acid dissociation. The calculations in Part (b)(ii), Part (c) and Part (d) were generally well answered with many candidates scoring full marks. Most candidates scored full marks in Part (e).

Assessment Unit A22 Analytical, Transition Metals, Electrochemistry and Organic Nitrogen Chemistry

Summary points

- Organic connectivity was poor particularly with condensed structural formulae for NH_2 and NO_2 groups.
- Conventional cell representation was not well answered with Pt and H^+ being the omissions most frequently seen for those who could attempt an answer worthy of some credit.
- Purification of an organic solid was often confused with an organic liquid.
- Oxidation states and charges were often confused which was penalised.

Multiple Choice Questions 1 – 10

The multiple-choice questions were generally well answered. Candidates appeared to be most challenged by question 6. Question 10 which was a simple definition of base peak in mass spectrometry was the best answered.

Q11 In Part (a) candidates were asked to explain the term **bidentate ligand**. Both terms were in bold so the explanation had to define both. “Molecule or ion” was most often missed from the ligand part of the definition and some missed parts of the bidentate with “in a complex” or “central” most frequently missed. In Part (b)(i) candidates responded well in terms of the number of co-ordinate bonds broken and formed but less well with the type as in Ni–O. In Part (b)(ii) most candidates gained both marks but some lost marks for 4 to 7 molecules in place of moles or species. Part (b)(iii) was well answered and most errors were in giving the oxidation state as a charge which was penalised. The shape of the complex was also more poorly answered than expected. In Part (c)(i) candidates were asked to write an equation for the formation of a given complex from the hexaaquachromium(III) ion. The most common errors were charges not being correct or missing or given as oxidation states, incorrect balancing, water not present as a product and sometimes nickel was used in place of chromium. The trans isomer in Part (c)(ii) was well answered but incorrect 3D drawings were common and a “different” cis isomer was common as well. In Part (d)(i) oxidation states were again given as charges which was penalised and many candidates did not pick up the change in the oxidation state of carbon. For Part (d) (ii) most candidates were able to write the iron(II) oxidation half-equation and some managed the manganate(VII) reduction but only the most able correctly gave the ethanedioate oxidation half-equation. The colour change in Part (d)(iii) was well known but some gave it the wrong way round and some used purple rather than pink which was not credited. The calculations in Part (d)(iv) and Part (v) proved challenging – the most common errors were using a 1:5 ratio rather than the 6:10 ratio and not answering to the correct appropriate number of significant figures in (iv). The degree of hydration proved more challenging in Part (v) with some candidates not realising they needed to use their answer from Part (iv).

Q12 The name of the polymer polyethylene terephthalate in Part (a)(i) was not well known with the abbreviation PET often given which was not credited. The full name is given in the specification and was expected. The structure of the repeating unit of the polymer was well answered in Part (a)(ii) with common mistakes being an oxygen missing or less frequently the bonds coming out the side missing. In Part (b)(i) almost

all candidates recognised hydrogen bonds from the diagram of Kevlar but frequently the explanation of why Kevlar has such a high melting point was not credited as it missed the idea of between the molecular or between the polymer chains. In Part (c) many candidates scored at least one mark for hydrolysed by microorganisms but the other mark for recognising that the amide and ester groups are being hydrolysed was less often awarded. Amide and ester **bond** was not credited.

- Q13** This was a wide-ranging question on amino acids and chromatography. Most candidates were able to draw the structures of glycine and alanine in Part (a). Common errors were with connectivity of the NH_2 group. Most scored well in Part (b)(i) naming 2-amino-2-methylpropanoic acid and common errors here were the wrong order of amino and methyl, “methy” as opposed to methyl and hyphens missing. The structure and name of the aldehyde or ketone needed to form valine was well answered in Part (b)(ii). The equations in Part (b)(iii) and Part (iv) caused issues with brackets in condensed structural formulae, for example $\text{CH}_3\text{CHNH}_2\text{CN}$ was not credited. Brackets are required for substituent groups of more than one atom in the middle of a condensed structural formula. The same was applied in Part (b)(iv). Other common errors were missing H_2O or ethanal written as CH_3COH in Part (iii) but candidates were able to gain one mark in (iv) if they formed NH_3 rather than NH_4Cl . The structure of lysine at pH 1 was relatively well answered with common errors being the zwitterion structure given or only one NH_2 group protonated. The two dipeptides in Part (c)(ii) were well drawn but some candidates did forget to circle the peptide group. The description of the secondary structure of a protein in Part (d) was as given in the clarification of terms document. The most commonly missed marks were intramolecular hydrogen bonds or folding/bending rather than twisting/coiling. In Part (e)(i) candidates were asked to describe how two-way paper chromatography is used to separate lysine and valine from a mixture of amino acids. Common errors were a misunderstanding of the difference between chromatography paper and a chromatogram, limited detail about the pencil line near the edge of the paper, spotting of lysine and valine, not mentioning spotting, not drying between runs and using a chemical developing agent after the first run. In Part (e)(ii) many scored well for how to locate and identify lysine and valine from the chromatogram. Most common omissions were not locating the amino acids or incorrect description of how to calculate R_f values. Some had idea of “measuring” R_f values which was not credited. Part (e)(iii) required the idea of better separation which was relatively well answered.
- Q14** The definition of a transition metal and the explanation of why vanadium was a transition metal in Part (a) was reasonably well answered with most having the idea of a partially filled d subshell. However some candidates did fail to give the correct electronic configuration of vanadium or one of its stable ions. The colour changes in Part (b) were well recalled but candidates struggled with the half-equations with V^{5+} and V^{4+} being common despite the formulae of the ions being given in the table. Part (c)(i) was well answered with candidates able to write the ionic equation from the two given half-equations. Sometimes the final equation was the wrong way round. The conventional cell representation in Part (c)(ii) was not well answered with many not understanding the difference between commas and phase boundaries. Pt was often missing as were H^+ ions in the reduction cell. The negative electrode was relatively well known in Part (c)(iii) as the vanadium electrode and the explanation in terms of oxidation or loss of electrons was again well answered. Most were able to calculate the emf of the cell in Part (c)(iv). Missing units were penalised but 1.49 V was allowed. However from 2023, the positive sign will be expected. In Part (d) most could describe some of the features of the standard hydrogen electrode and common errors were not indicating that hydrogen was at 100 kPa or 1 atm pressure, just a general statement of pressure was often given. The details of the $\text{VO}_2^+/\text{VO}^{2+}$ electrode

were not often awarded with many only thinking one ion was in the solution with a vanadium electrode. This limited candidates to 4/6 in this QWC question. The actual description of the setup of the overall cell was sometimes muddled.

Q15 In Part (a)(i) the reagents and conditions for the formation of the diazonium ion were partially known. Often it was confused with nitration or reduction using Sn and HCl. The temperature and HCl were often awarded. Nitrous acid was not awarded as it was the reagents required. The IUPAC name for resorcinol was well attempted in Part (a)(ii) by most candidates with several names being accepted based on candidates' knowledge. Commas and hyphens had to be correct. "Di" was most often missed in 1,3-dihydroxybenzene. The structure of the azo dye in Part (a)(iii) was accepted with any connection point of resorcinol to the azo group. If the structure did not have an azo group, zero marks were awarded. Missing groups were common and poor connectivity of the NO₂ group was also very common and both were penalised. If the NH₂ group remained on the 4-nitrophenylamine ring, no marks were awarded. The explanation of why magnesium I is coloured in Part (a)(iv) produced a variety of answers and most gained at least 1 mark for understanding that light was absorbed in the visible region or words to that effect. Extensive delocalisation was expected along with some indication of energy levels being closer together. Common errors were to omit the idea of extensive or not wording the absorption of some visible light correctly. In Part (b)(i) most worked out that ethanoyl chloride would be the reagent required, some suggesting ethanoic acid which was not credited. A formula was also not credited here as the name was asked for in the question. The molecular formula should be of the form C₈H₈N₂O₃ in Part (b)(ii) and often some form of condensed structural formula was given which was not credited. The QWC question on the purification of the solid 4-nitrophenylamine in Part (b)(iii) was poorly answered as most gave details about liquid purification and any mention of any terms to do with liquid purification were penalised. Many gained 2 indicative points for how the purity of the solid could be confirmed gaining 2 marks overall. For those who did describe the solid purification, the steps must contain all the key terms. Suction filtration cannot be used in place of filtration whilst hot. In Part (c)(i) a structural equation was expected to show the position of the groups on the benzene rings. Many struggled with the balancing of this equation in terms of 6[H] and 2H₂O. Others included 6H⁺ ion place of 6[H]. A condensed structural equation gained a maximum of 1 mark and errors in connectivity of the NO₂ group and lack of brackets in the form of C₆H₄(NO₂)NH₂ were also penalised.

Assessment Unit A23: Further Practical Chemistry Booklet A

Summary points

- The mark scheme was widened in Question 1, with a number of alternatives being accepted, which took account of the variety of responses by candidates/centres.
 - A surprising number of candidates did not score highly in the titration in Question 2 as the table was poorly completed.
- Q1** Most candidates correctly described the appearance of the two iron salt solutions in Part (a). In Part (b), a range of pH values were accepted. In Part (c), a number of candidates correctly identified the colours but did not state that precipitates formed. A significant number of candidates did not make reference to the formation of a precipitate in Part (d) whilst many made reference to the formation of white or steamy fumes which was not credited. A variety of colours were accepted in Part (e) and Part (f), with many identifying the colour with iron(III) and thiocyanate as blood red, suggesting they are familiar with it despite it not being on the specification. In Part (g), some candidates gave a correct observation in (i) but did not make reference to it in Part (ii) and so lost the mark. Most candidates correctly explained which solid contained salicylic acid in Part (h).
- Q2** A small number of candidates did not give the mass of tablet to one decimal place in Part (a). Most candidates scored full marks for the observations in Part (a) and Part (b); credit was given in Part (c) for alternative colours if candidates/centres used a flavoured (and coloured) indigestion tablet, e.g. orange. A surprising number of candidates did not score full marks in Part (d). Common errors included incorrect headings, not giving data to at least one decimal place, the rough titre value not being higher than the accurate titres and units not being included with the mean titre value calculated.
- Q3** Most candidates scored full marks in this question, with correct observations routinely seen in Part(a), Part (b) and Part (c).

Assessment Unit A23: Further Practical Chemistry Booklet B

Summary points

- Many candidates had a poor understanding of the Chemistry involved in Question 1.
 - The standard of calculations was high, with many candidates scoring full marks.
 - A surprising number of candidates did not score full marks for the diagram of Büchner filtration apparatus.
- Q1** Most candidates scored full marks for the graph in Part (a) although a small number of candidates lost marks for incorrectly labelling the axes. In Part (b), some candidates did not include a unit and so lost the mark. Only the most able candidates correctly explained the use of large excesses of propanone and sulfuric acid in Part (c). The use of sodium hydrogencarbonate was better understood in Part (d). Most candidates did not understand the question in Part (e)(i) and instead made references to interpreting graphs. Similarly, the shape of the graph and how it related to the order of reaction with respect to iodine in Part (e)(ii) was not interpreted correctly by a significant number of candidates. The most able candidates handled these question

parts well and correctly explained why the rate determining step given in Part (e)(iii) was consistent with the graph. Most candidates gave the correct colour changes in Part (f)(i) although some simply listed one colour for each point in the titration. The most able candidates correctly explained why starch is not added at the start of each titration in Part (f)(ii).

- Q2** A surprising number of candidates incorrectly answered Part (a)(i), with many giving 25 cm^3 . An error in this question part was carried forward into Part (a)(ii) and Part (a)(iii), which were answered well by most candidates. The sketch in Part (b) was drawn poorly by a significant number of candidates. Common errors included the drawn curve not starting at the same point as the original curve, the vertical section at the wrong point on the horizontal axis and the vertical section starting too low on the vertical axis. The definition of a buffer was well known in Part (c)(i). Candidates were credited with both marks if they gave the correct relevant equation in Part (c)(ii). Most candidates correctly explained why a solution of sodium ethanoate has a pH above 7 in Part (d). In Part (e), a surprising number of candidates gave phenolphthalein as an answer which suggests they did not read the question or understood it fully. Some correctly identified thymol blue as the correct indicator but did not correctly relate the pH range of the indicator to the vertical section of pH curve.
- Q3** Most candidates were unable to apply knowledge of the use of the sodium salt of aspirin to this context in Part (a). The meaning of the term *in situ* was generally well known by most candidates as was the equation for the formation of nitrous acid in Part (b)(ii). Only the most able candidates understood the use of crushed ice and confused it with the formation of a precipitate which was not credited. Some candidates made reference to the stability of nitrous acid rather than the diazonium ion. The volume was calculated correctly by most candidates in Part (c)(i). The equation in Part (c)(ii) was answered very poorly and only a very small number of candidates understood it as an acid base reaction. The vast majority of candidates correctly identified the use of methyl orange as an indicator. The diagram for Büchner filtration was poor by most candidates, with many completely wrong and others missing labels or with incorrect labels. This was surprising as the diagram has been asked in previous series. Most candidates scored at least one mark in Part (e)(ii) and the description of melting point determination in Part (f)(i) was generally well answered. Most candidates scored at least one mark in (f)(ii) by stating that the melting point range would be larger. The calculations in Part (g)(i) and Part (g)(ii) were well answered by most candidates although some candidates did not realise they had to calculate the number of moles of both reactants in Part (g)(i) and based their answer on the masses of the two reactants given in the question.
- Q4** Most candidates correctly identified the presence of the two chlorine isotopes in Part (a)(i); some candidates incorrectly referred to the presence of carbon-13. Most candidates correctly identified the fragment ion in Part (a)(ii) and also scored the available marks in Part (b)(i) and Part (b)(ii). The interpretation of the nmr data was correctly answered by most candidates in Part (b)(iii). Whilst most candidates correctly identified the structure in Part (c), some candidates drew an acyl chloride despite the question stem indicating that the compound was not an acyl chloride. There were many incorrect responses in Part (d) as only the highest performing candidates correctly described the correct test for a carbonyl group.

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