

A Level

Chemistry

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A LEVEL
(former Cambridge linear syllabus)

A 9254

CHEMISTRY

REPORT ON COMPONENTS
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CHEMISTRY

GCE Advanced Level 9254

| Component | Content | Page |
|-----------|-----------------------------------|------|
| 9254/01 | Chemistry: Theory | 1 |
| 9254/02 | Chemistry: Structured Questions | 5 |
| 9254/03 | Chemistry: Multiple Choice | 7 |
| 9254/04 | Chemistry: Option Topics | 9 |
| 9254/05 | Chemistry: Practical | 12 |
| 9254/07 | Chemistry: Extended Investigation | 17 |
| 9254/09 | Chemistry: Skills Assessment | 18 |
| 9434/00 | Chemistry: Special Paper | 19 |
| * | Grade Threshold | |

9254/01 - Chemistry

Answers to Numerical Calculations

- 1 (b) (i) P: ^{14}C Q: $[\text{}^{14}\text{N}]^{3-}$ R: $[\text{}^{15}\text{O}]^+$
- (c) (iii) ^2He : 2.00°
 ^3He : 2.67°
- 2 (c) (i) $pV = 2280 \text{ m}^3 \text{ Pa}$
 $2190 \text{ m}^3 \text{ Pa}$
 $2140 \text{ m}^3 \text{ Pa}$
- (iii) $V_{\text{graph}} = 2.25 \times 10^{-3} \text{ m}^3$
 $V_{\text{ideal}} = 2.37 \times 10^{-3} \text{ m}^3$
- 3 (b) $\Delta H_f = -1121 \text{ kJ mol}^{-1}$
- 4 (b) (i) $E^\circ_{\text{cell}} = +0.56 \text{ V}$
(ii) $E^\circ_{\text{cell}} = +0.79 \text{ V}$
- (c) (i) BaFeO_4 oxidation number = +6
(ii) $2.25 \times 10^3 \text{ C}$
- 5 (c) 1.6 g
- 8 (b) $M_r = 57.9$

General Comments

The overall standard of entry was marginally higher than in previous years, and this was reflected by a slightly higher average mark. Only a very few candidates did not finish the paper: most were able to complete it in the allotted time.

The quality of presentation was variable. Most scripts were well organised and legible, although some candidates answered parts of some their questions all over the place. This makes it difficult for the examiner to ensure that due credit has been given, and is to be discouraged. Candidates are reminded of the need to include ALL atoms in an organic structural formula as mentioned in the syllabus – carbon atoms with 'bonds' sticking out of them are *not* taken to imply hydrogen atoms.

Comments on Individual Questions

Question 1

(a) This was intended to be an easy 'bookwork' start to the paper. Whilst most candidates scored full marks on part (i), few scored a mark for part (ii). The definition, that isotopic mass is the mass of 1 mole of atom of an isotope relative to 1/12 the mass if a mole of ^{12}C atoms, was either totally missing from scripts, or quoted incompletely. Part (b) was well answered on the whole, although many candidates did not write the atomic symbols for the elements concerned (C, N and O), and several did not respond to part (ii). In part (c) most scored a mark for (i), but some candidates lost it through not giving the reason that the plate must

have been negative (e.g. that nuclei are positive and are attracted to it). Part (ii) was often answered in terms of mass only, rather than the charge/mass ratio and this lack of understanding caused part (iii) to be answered correctly by only the most able candidates.

Question 2

(a) In general the assumptions of the kinetic theory were well known, but some candidates threw marks away by not being precise enough, or not thinking about what they were writing. Common examples were 'the volume of the gas is zero' (rather than gas *molecules*); 'the gas particles have zero mass' (rather than zero volume). Accepted answers included *no intermolecular forces of attraction, elastic collisions, no loss of kinetic energy on collision* (not just 'energy'), *molecules having zero volume*. Random motion was not accepted as a distinguishing feature of ideal gases – real gas molecules move randomly too. Several candidates thought incorrectly that the non-ideality of CO_2 was due to the strong covalent bonding within the molecule. Part (b) was answered well. In (c) the graphs were generally plotted well, although those who had scaled their y-axis from 0-2400, and hence ended up with a virtually horizontal line, were penalised. Part (c)(ii) proved to be a good discriminator, the less good candidates suggesting that pV was proportional to p . The difference between the two values in (iii) is due to extra intermolecular attractions in CO_2 , due to its larger number of electrons.

Question 3

(a) This was virtually a GCSE question, but many candidates scored poorly. Many interpreted the question incorrectly, giving reasons for the difference in melting point, rather than the difference in bonding. This is due to Mg and F differing greatly in electronegativity, whereas S and F do not. Most candidates stated that the MgF_2 was ionic, but several then went on to draw shared pairs of electrons between the Mg atom and each of the F atoms. Some omitted the lone pairs on S and F in SF_2 . The Born-Haber cycle in (b) was well-drawn by many candidates – but some threw marks away by not being careful enough with state symbols. Most candidates did not appreciate that the F-F bond had to be broken, so did not include the bond energy term in their calculation. Another mistake was to assume that only the second ionisation energy was needed to obtain Mg^{2+} from Mg, rather than the sum of the first and second. Expected answers in (c) were that S could expand its octet and form two more S-F bonds, whereas for Mg, the third and fourth ionisation energies are prohibitively high for further ionisation to take place. Reasons based on the stability of the filled shell in magnesium were ignored, but an appreciation that further electrons would have to be taken from an (inner) shell nearer to the nucleus was given credit. Both reasons were needed to gain the two marks.

Question 4

(a) The electronic configuration of chromium was well known, or could easily be worked out by most candidates. Either $[\text{Ar}]3d^44s^2$ or $[\text{Ar}]3d^54s^1$ was accepted. Any two oxidation states from +1 to +6 were allowed, but *not* the formulae of ions, except for Cr^{2+} and Cr^{3+} both of which do exist as stable entities (e.g. Cr^{6+} was not given credit, but Cr(VI) or Cr(+6) was allowed). There were some excellent answers to part (b). This proved, as always, to be an excellent discriminator. Weaker candidates did not think clearly enough about the species involved – some oxidised Fe^0 or SO_2 or SO_4^{2-} (to $\text{S}_2\text{O}_8^{2-}$) in (i) whilst others seemed to misread the question completely, and used MnO_4^- as the oxidant. One fairly common error was to calculate the E^\ominus correctly but not to balance the electrons in the two half equations. The empirical formula calculation in (c) was well done by most, although some used atomic numbers rather than atomic masses as denominators. Many calculated correctly the oxidation number of iron (= +6), but then failed to use this factor in part (ii).

Question 5

(a) The shapes of SO_2 (bent) and SO_3 (trigonal planar) were well-known by many candidates, but some had not considered how these shapes arose from the electron distribution. Few clearly stated that SO_2 has one lone pair, whilst SO_3 has none. The examiners were very surprised to see so many poor answers to part (b). This used to be a standard, classic 'bookwork' reaction, subject to usual equilibrium constraints, but nevertheless carried out at a fairly high temperature (to increase the reaction rate) and a low pressure (because the yield is already high enough). By contrast, the reason for dissolving the SO_3 in conc. sulphuric acid rather than water was known by the majority. The origin of the SO_2 by burning S in air was not known by some. One candidate thought up a use for the surplus low level ozone in our 21st century environment: $\text{S} + \text{O}_3 \rightarrow \text{SO}_3!!!$

The calculation in (c) often omitted the factor of $50/10^6$, and often used 64 ($M_r(\text{SO}_2)$) rather than 32 (A_r of S)

Question 6

(a) Although most candidates recognised the *cis-trans* isomerism in hex-3-ene (but several thought the isomers included hex-2-ene or even 4-methylpent-1-ene), the name 'cyclohexene' often did not conjure up the correct structure for them. Many either thought it meant cyclohexane, C_6H_{12} , or thought it was benzene, C_6H_6 . Those that did recognise it as a six-membered ring with one double bond in it found it difficult to express in words the essentials of the situation: The ring is too small to support a *trans* double bond – only the *cis* isomer can exist. Only the most able candidates scored this mark. The mechanism of electrophilic addition in (b) was fairly standard bookwork. Conditions required were 'in the dark' or 'in a solvent' or 'at room temperature'. Mention of light (ultra violet or sunlight) or Lewis acid catalysts negated this mark. Many candidates are not clear on the use of curly arrows or δ^+ / δ^- partial charges. Several drew an arrow *from* the Br_2 to the double bond. Some polarised the Br_2 as $\text{Br}^+ - \text{Br}^-$, rather than $\text{Br}^{\delta+} - \text{Br}^{\delta-}$, whilst others drew the intermediate as $>\text{C}(\text{Br}) - \text{C}^{\delta+} <$, rather than $>\text{C}(\text{Br}) - \text{C}^+ <$. The key point in (c) was that the double bond (and hence any isomerism due to it) is destroyed during the reaction, only to be replaced by the *optical* isomerism in the product $\text{C}_2\text{H}_5\text{CHBrC}_3\text{H}_7$. Two groups suffer oxidation in (d): the $-\text{CH}_2\text{OH}$ is oxidised to $-\text{CO}_2\text{H}$, whilst the $\text{C}=\text{C}$ double bond splits, each end being oxidised to $-\text{CO}_2\text{H}$. Many lost a mark here, for stating that the final oxidation products were aldehydes, rather than acids.

Question 7

(a) Conc. HCl was a common wrong reagent for reaction I. PCl_5 , PCl_3 or SOCl_2 were all acceptable. NH_3 (preferably NOT aqueous) was correct for II. The functional group in (b) is a (di)amide, whose formula is $\text{H}_2\text{NCOCH}_2\text{CH}_2\text{CONH}_2$. The commonest error was to take the molecular formula..... N_2O_2 to mean either two NO groups, or a NO_2 group. Part (c) was answered well (reduction) as was part (d). Some candidate lost marks for stating 'addition polymerisation' rather than 'condensation polymerisation', and for leaving the ends of the repeat unit as $\text{ClCO}\cdots\text{NH}_2$. A correct version would be $[-\text{COCH}_2\text{CH}_2\text{CONHCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}-]$. The explanation for the enhanced reactivity in (e) was expected to emphasise that the nucleophilic H_2O would be more attracted to the δ^{++} C of the $(\text{C}=\text{O})\text{Cl}$ than to the δ^+ C of the $-\text{CH}_2\text{Cl}$ group, it being more δ^+ due to the electronegativity of oxygen. In (f), dehydration or condensation was accepted as the reaction type, with the correct monoester $\text{HO}_2\text{C}-\text{CH}_2-\text{CH}_2-\text{CO}_2\text{C}_2\text{H}_5$ scoring [2] marks, whilst the diester $\text{C}_2\text{H}_5\text{O}_2\text{C}-\text{CH}_2-\text{CH}_2-\text{CO}_2\text{C}_2\text{H}_5$ scored [1].

Question 8

(a) Many candidates correctly deduced the formula for calcium ethanoate $[(\text{CH}_3\text{CO}_2)_2\text{Ca}]$. Often those that did not do so had forgotten that the calcium ion is Ca^{2+} or that the formula for ethanoic acid is $\text{CH}_3\text{CO}_2\text{H}$. Some candidates did not even know the formula for calcium carbonate. The calculation in (b) was fairly competently done by most. Factors of 10^3 were missing in some, however. In (c) many candidates explained their reasoning well – responses to these sorts of questions are becoming more logically set-out – but there were still some who contented themselves with a bald statement that G was propanone, and expected to gain full marks. The arguments that scored marks were: G is water soluble because it is polar or hydrogen bonded; G cannot be an acid because it is neutral; G is not an aldehyde (no reaction with Fehling's reagent); G is not an alcohol or containing an OH group (no reaction with sodium); G is a methyl ketone (iodoform reaction). Part (d) was a straightforward piecing together of previous formulae, but some candidates tried to make it more complicated than that. A suitable test in (e) would have been 2,4-DNPH, giving an orange precipitate. A surprisingly large number of candidates suggested $\text{CH}_3\text{CH}_2\text{COCH}_3$ in (f), rather than the correct $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$.

9254/02 – Chemistry (Structured Questions)

General Comments

This paper produced a wide range of answers. Some candidates scored full marks on this paper; others found some questions very difficult.

Comments on Individual Questions

1. An unusual pH curve as magnesium hydroxide is precipitated when NaOH(aq) is added to MgCl₂(aq). A common error in (a) was the formation of NaCl(s). The 'end -point' is after 20 cm³ of NaOH so that the concentration of the original MgCl₂ is 0.20 mol dm⁻³. At a pH of 9.0, [OH⁻] = 10⁻⁵ and in (c)(ii) [Mg²⁺] = 0.10. These values give the K_{sp} of Mg(OH)₂ to be 10⁻¹¹ mol³ dm⁻³. As usual in calculations the candidate's results were used in the marking method of error carried forward (ecf). (e) is a dilution; it is as if 10 cm³ of 1.0 mol dm⁻³ NaOH(aq) is diluted to 80cm³, so that [OH⁻] = 0.125 mol dm⁻³ which gives a pH of 13.1. It is wondered if this experiment might make the subject of a practical extended study for Paper 7. Freshly precipitated Mg(OH)₂(s) can be colloidal and might not give the pH curve ideally represented on page 2. Would the precipitation be more crystalline from hot solutions? Might be worth investigating.

2. This is a straightforward question and well-trained candidates scored good marks.

3. (a) The oxidation states of N in its compounds is good teaching material for it shows compounds in every state from +5 to -3. This question is founded on this plurality of oxidation state.

Some candidates found the question difficult. The equations in (b) can be deduced from the electrode processes given in the *Data Booklet*. In (c) it was the intention that candidates should build the final equation from the structures of (i) to (iii). The final problem is to balance the necessary H⁺ and H₂O to give



4. Although *fluothane* is now seldom used as an anaesthetic, it makes a suitable molecule to ask questions about halogen chemistry from the Inorganic and the relative strengths of the C-Hal bond from Organic Chemistry. The answers are straightforward and are given in the mark scheme. A common error was in (c)(ii) not to recognise that this was the reaction of chlorine with bromide ions. State symbols were not asked for but the equations – all straight forward – did require balancing.

5 (a) A common error was to assume that NaOH (aq) is a solvent – more polar than water itself – and to use this to explain the solubility of the phenol. NaOH (aq) is a *reagent* and forms the ionic salt, the phenoxide, and this is soluble.

(b) In (b) the diol is formed in (i). In (ii) the best answer would be ArCO₂H, but this was seldom given. Such a strong oxidant would remove side chains to benzoic acid derivatives. There are two reactions with the Br₂(aq) – aromatic substitution and saturation of the side chain. In (c) addition polymerisation of the alkene occurs. In questions of this sort the rest of the molecule can be represented as Ar - .

6 This question produced longer written answers so that Examiners could award the Quality of Language marks with plenty of material. The main process in (a) is fractional

distillation, and it was hoped that the examples asked for would include gases used as fuels and chemical feedstock, gasoline, diesel, bitumen etc. The manufacture of aromatic hydrocarbons by the chemical petroleum industry involves reforming the molecules and the removal of hydrogen to give benzene derivatives.

A representative equation was expected in (b) and the usefulness of alkenes e.g. ethene given by reference to plastics, ethanol etc.

UCLES

9254/03 – Multiple Choice

General Comments

For this paper, the mean score was 22.9 (57.2%), just below the targeted value, and the standard deviation of the scores was 7.28 (18.2%), indicating that the performance of the paper was very satisfactory.

The first 30 questions were simple completion items: *Qs 31 to 40* were three-statement multiple completion items.

Comments on Individual Questions

Only two question had a facility above the design limit. Candidates were clearly aware of the contribution of vehicle exhaust gases to acid rain (*Q.20*) and of trends in physical properties down a group such as the Group II metals (*Q.36*).

Unusually one question had a facility below the design limit: whereas *Q.9* discriminated well within the ability range of candidates, a greater proportion of candidates chose option **D** rather than the key **C**, indicating that many candidates would not be familiar with the practical aspects of determining the progress of a reaction by a titrimetric method.

The answers to *Q.33* clearly reflected a wide understanding of the Boltzmann distribution of molecular speeds within a gas: it had a high facility (78%) which was coupled with a slightly low ability to discriminate within the ability range of candidates.

All other questions performed within the design limits, but in three questions a higher proportion of the more able candidates chose a distractor rather than the key.

Q.14 This question was based on the analysis of the gases from the combustion of carbon disulphide – carbon dioxide and sulphur dioxide – by their absorption in aqueous sodium hydroxide. Such a question involves a simple calculation of molar proportions by comparison of the volumes of the gases, and the examiners intentionally made this a simple matter by making the final total volume 100 cm³. Nevertheless 26% of candidates, in choosing the distractor **A**, did not appreciate that SO₂ is an acidic gas and would be absorbed as well as the CO₂.

Q.21 This question was based on the mechanism of the free radical substitution of alkyl groups, and specifically asked what compounds could be obtained in trace amounts from the irradiation of a mixture of CH₃Cl and Cl₂. The phrasing 'trace amounts' should have indicated the combination of two free radicals, and the correct answer **C** was CH₂Cl/CH₂Cl by joining two CH₂Cl• free radicals. But a small proportion of the more able candidates chose the distractor **D**, CH₃CH₃: the free radical CH₃ is *not* obtained by the attack of another free radical on CH₃Cl.

Q.27 The herbicide *Karbutilate* contains both amide and ester linkages, and both these linkages are hydrolysed by boiling aqueous sodium hydroxide. 46% of candidates, in choosing the distractor **D**, failed to recognise the ester linkage.

Two other questions deserve comment as, although they performed satisfactorily, a higher proportion of all candidates chose a distractor other than the key option.

Q.5 41% of candidates chose **A** rather than **C**, implying that the volume of an ideal gas is zero at °C.

Report on the Components taken in June 2000

Q.25 Candidates were asked about the best procedure to obtain a high yield of the ester ethyl ethanoate from ethanoic acid and ethanol. 47% chose **D** first refluxing ethanol with concentrated sulphuric acid (which must give a high proportion of ethene) before adding the ethanoic acid.

References are given to the Assessment Objectives with each section of the Syllabus

| <i>Item Number</i> | <i>Assessment Objective</i> | <i>Item Number</i> | <i>Assessment Objective</i> |
|--------------------|-----------------------------|--------------------|---|
| 1 | 1(g) | 21 | 10.2(c) |
| 2 | 1(b) | 22 | 10.3(a)(ii) |
| 3 | 2(i) | 23 | 10.4(f),(g) |
| 4 | 3(b),(l); 9.1(l) | 24 | 10.5(c) |
| 5 | 4(c) | 25 | 10.6(b)(ii),(g) |
| 6 | 5(b)(i),(c) | 26 | 10.6(b)(i),(iii); 10.4(b)(ii),(iii),(g) |
| 7 | 5(c) | 27 | 10.7(g); 10.6(h) |
| 8 | 6(a); 8(i) | 28 | 10.7(e) |
| 9 | 7(d),(e); 8(e) | 29 | 10.8(b)(i) |
| 10 | 8(i)(i) | 30 | 10.8(f) |
| 11 | 8(b)(i) | 31 | 2(i);9.1(d) |
| 12 | 9.1(a),(d),(f) | 32 | 3(c) |
| 13 | 9.2(c),(d) | 33 | 4(a),(c);8(h) |
| 14 | 1(h)(ii),9.1(h); 9.3(d) | 34 | 7(b),(j) |
| 15 | 9.4(h) | 35 | 9.1(l) |
| 16 | 9.5(h)(i) | 36 | 9.2(e),(f);2(i)(ii);6(b)(f) |
| 17 | 9.6(c) | 37 | 9.3(c),(d),(e) |
| 18 | 9.6(f),(g),(l) | 38 | 10.1(i) |
| 19 | 10.1(b)(iv),(v);10.2(h)(i) | 39 | 10.4(b)(ii),(vii) |
| 20 | 10.2(l);9.6(g) | 40 | 10.5(a),(b),(c) |

9254/04 - Chemistry: Option Topics

General Comments

The paper generally performed well, producing a good spread of marks with few 'dead' marks in the major options. As in previous years Phase Equilibria, Transition Metals and Biochemistry remain the most popular options, together with a significant number choosing to answer questions from the Spectroscopy option. This year also saw a marked increase in the number of candidates answering questions from the Environmental Chemistry option. Very few candidates failed to attempt four questions, suggesting that candidates in general were not short of time on this paper.

As has been mentioned on numerous previous occasions, a number of candidates lost marks by failing to read the questions properly. This not only loses marks, but also wastes candidates' time.

Biochemistry

Biochemistry continues to be one of the more popular options, and although this set of questions produced some very good answers from candidates, some found them rather more challenging than in previous years. Pleasingly, few candidates attempted to answer questions from a strictly biological perspective and this resulted in rather higher quality answers.

- Q1 This question was answered well on the whole, although a surprisingly large number of candidates failed to identify four types of R group interactions in part (b).
- Q2 A significant number of candidates failed to score full marks in part (a), describing the structure and function of haemoglobin. This was largely due to a lack of detail in the answers provided. Parts (b) and (c) were generally tackled successfully, but a surprisingly large number of candidates failed to identify 'rate of reaction' in part (d).
- Q3 This was the lowest scoring of the three questions. Part (a) of this question was generally well understood, with strong candidates scoring full marks. Parts (b) and (c) caused more problems, with candidates failing to give the detail required to score full marks

Environmental Chemistry

Once again this option increased its share of candidates, and candidates' answers to the questions continue to improve. The examiners were pleased to see some excellent answers to all three questions.

- Q4 It was clear from candidates' answers that this material had been well covered by teachers, with part (a) generally well answered. Part (b) was often poorly answered, with candidates failing to give a valid source of nitrogen monoxide and/or unable to show how the gas is involved in the destruction of ozone.
- Q5 This question was familiar territory for candidates, yet few scored top marks. Part (a) was generally well answered, but marks were surprisingly dropped in part (b). This area has proved difficult for candidates in the past and could perhaps benefit from some extra attention in future.

- Q6 This question proved to be a good discriminator of candidates, with many picking up good marks in part (a) but only the better candidates scoring well in part (b). The only part which produced few good answers was (b)(iv).

Food Chemistry

A rather smaller number of candidates answered questions from this section than in recent years and these seemed to find it more difficult to score well, although there were some good answers.

- Q7 This question produced the highest marks in this topic. Answers to part (a) were generally accurate, but in part (b), some candidates gave poor descriptions of the action of emulsifying agents. In part (c) and (d), most candidates were able to give reasonable answers.
- Q8 This was the least popular of the questions from this option, and the lowest scoring. Although almost every candidate knew that sucrose was a disaccharide, few could adequately describe the hydrolysis to form 'invert' sugar, or explain what 'invert' meant. Part (b) was poorly answered, with few candidates showing that they knew much about jams and their production.
- Q9 This question produced a wide range of marks, but very few candidates scored full marks. Many lost marks by failing to point out that spoilage started with autolysis of the food, allowing attack by various micro-organisms. The effects of the different categories of micro-organism were generally well known. In part (b) weak candidates found it difficult to apply their knowledge to suggest reasons why vinegar is not distilled to give a more concentrated product.

Phase Equilibria

This remains one of the most popular of the options with very large numbers of candidates choosing it. As is generally the case, the questions produced a good spread of marks, although the performance on this set of questions was significantly lower than in previous examinations.

- Q10 Parts (a) and (b) were generally well answered by most candidates, and part (c) caused few problems for good and moderate candidates. It was part (d) that caused the majority of errors in this question with many candidates failing to appreciate the role of atomic radii in the structure of mixtures of metals.
- Q11 Although part (a) should have been routine for candidates studying this option, a surprisingly high number failed to describe equilibrium situations in their answers, or to mention atmospheric pressure when describing 'boiling point'. Part (b) was generally satisfactorily answered, for routine book-work. Answers in part (c) often focussed on reduced access of water molecules to the surface, rather than on a reduction in vapour pressure due to the attraction of ions.
- Q12 This was the least popular of the questions on this option, and gained the lowest marks in general. Candidates often failed to show that they understood the principles behind GLC and even made simple arithmetical errors in part (b).

Spectroscopy

Although not one of the most popular, this option continues to attract a reasonable number of centres, and the examiners saw good answers to all three answers. Of the three questions, Q13 was perhaps the most straightforward and question 14 the least popular with candidates seemingly put off by its rather complex appearance.

- Q13 This was the most popular and best answered of the Spectroscopy questions. Part (a) proved to be routine for many candidates, although a significant number failed to score full marks, omitting key elements. Part (b) required rather more application of knowledge and proved to be a good discriminator, with good candidates scoring full marks.
- Q14 This question was relatively unpopular, perhaps due to the unfamiliar nature of the compounds. In fact, part (a) relied on candidates identifying key structural features in the two compounds, and those who persevered scored well. Part (b) was a variation on questions based on acid-base indicators but here again the unfamiliar nature of the compound seemed to cause problems.
- Q15 This question was answered well by many candidates. In part (a) good candidates homed in on the peak at m/e 43 as the key point to compound P in spectrum II, and then proceeded to identify the fragments in each spectrum from the parent molecules. Almost everyone could do the calculation of the number of carbon atoms. Part (c) proved to be the weakest, with a significant number of candidates failing to mention labelling with ^{18}O and how this would help identify the bond which is broken in the hydrolysis.

Transition Elements

This continues to prove a very popular option with some high-scoring answers. The answers given by some candidates this year lacked the detail necessary to gain full marks, and this resulted in rather lower marks than in some years.

- Q16 There was a wide range of marks for this question. Most candidates scored one of the marks in part (a) but many failed to point out that the more unpaired electrons a complex possessed, the greater the paramagnetism. Part (b) relied on candidates using the data in the questions, and a worrying number of candidates clearly failed to do so. Good candidates scored well on this part, with weak candidates failing to score more than one or two marks.
- Q17 In contrast to Q16, this question produced reasonable marks for many candidates. Most were able to score 5 marks in part (a) although only the good candidates scored all 7 marks. Part (b) was standard book-work, but weak candidates struggled to score more than one mark. Relatively few candidates used the Data Booklet adequately and scored all 3 marks.
- Q18 This question produced a good spread of marks, and it was pleasing to see how many candidates could work through the series of reactions. Weaker candidates struggled with equations and mathematics in part (b), whilst strong candidates deservedly gained high marks.

9254/05 - Practical Chemistry

General Comments

The Examiners thank those Supervisors who provided full sets of experimental results for Qs 1 and 2 as requested in the preparation instructions. The instructions for May 2000 also included a request for seating plans. These were provided by a minority of centres. Where problems arise with experimental results (as happens on occasions) it is helpful for the Examiners to be able to identify groups of candidates by examination session and laboratory. To ensure maximum benefit for candidates the Examiners would be pleased to see a set of Supervisor's results for each session and laboratory.

Accuracy marks in Q1 were assessed against the value provided by the Supervisor and in Q2 against the rise in temperature after addition of the magnesium powder.

There was little evidence that candidates ran short of time.

Comments on Individual Questions

Q1 The column labelled '*Rough*' was not included in the titration table for this paper as a number of candidates have in the past performed only the '*Rough*' plus one other titration. Under the existing mark scheme, this was penalised, even if the values were identical and both quoted to two decimal places. Some candidates this year labelled their first column as '*Rough*' but were not penalised in the revised mark scheme if they used this value in deriving a suitable average.

Centres are reminded of the guidance in the Practical Syllabus that the scales should be read to the nearest half of a division. For a Class B Burette this is to the nearest 0.05cm^3 . The examiners therefore expect to see final burette readings recorded to this accuracy, e.g. 25.00 cm^3 , 25.05 cm^3 or 25.10 cm^3 . Initial burette readings are acceptable to one decimal place or to a whole number as the candidate may have set the initial volume to a particular division or to a whole number as the candidate may have set the initial volume to a particular division mark on the burette. One mark was given for burette readings in the correct places in the table, final values recorded to two decimal places and a subtraction performed to obtain the volume of FA 2 added.

The examiners are always surprised to see candidates (and supervisors) who record burette readings such as 25.07 cm^3 , 25.13 cm^3 etc. This frequently is seen for all burette readings across a centre – is the equipment supplied above the Grade B requirement?

Centres are reminded of the guidance in the syllabus that examiners are looking for any two titres within 0.10cm^3 . Candidates having obtained two consecutive titres within 0.10 cm^3 often perform additional titrations. One mark is given for two titres within 0.10 cm^3 .

Many candidates record a valid titration value in the summary but fail to indicate by tick (or calculation) how they arrived at that value. One mark is given for indicating how this value is selected.

The end point for this titration was more difficult than usual with the Cr^{3+} colour mixed with the iodine colour before the end-point. The end-point itself was very precise, changing from the colour of starch-iodine complex to that of the chromium ion

with one drop addition of thiosulphate. A number of centres reported the return of the starch-iodine complex colour after the end-point. This did occur but only after a considerable period of time and should have caused no more difficulty than say an acid-base titration with phenolphthalein as indicator.

Marks for accuracy were obtained by comparing the titre in the summary (corrected if necessary) with the supervisor's value. 12 marks were awarded for a difference up to 0.10 cm^3 , falling by stages to zero for a difference greater than 1.50 cm^3 . Candidate's who performed only one titration or calculated an 'average' using widely spaced titration values were subject to a penalty on their accuracy marks.

Many centres were seen where titrations were very consistent across the centre and high accuracy marks awarded. Other centres had widely spread titration values and candidates who were not consistent across their individual set of titration values.

The calculations in parts (a) to (d) caused little problem for the majority of candidates.

A number lost one mark in part (a) by using 32 for A_r of S instead of the value of 32.1 given in the paper. Some candidates, having correctly calculated $37.23/M$, lost the second mark by introducing a volume ratio at this stage.

A minority of candidates incorrectly stated a 2:2 ratio in (c).

The calculation in (e) caused considerable problems for the majority of candidates and unfortunately the marks in (e) and consequentially those in (g) were seldom awarded. A number of candidates produced theory in this section - working from ionic equations. Having calculated the moles of CrO_4^{2-} added and moles of I_2 produced in (d) and (c) very few were able to relate this to the moles of iodide reacting despite the ionic equation given on the first page. One mark was awarded to candidates who calculated (c)/(d) and two marks to those who calculated $2(c)/(d)$. A further mark was given to candidates who calculated a correct value to within 1% of the correct value for their titration ($0.12 \times \text{titre}$)

Most candidates correctly identified the ion present at the end point as Cr^{3+} .

To gain the mark in (g), candidates had to make use of a value from (e) derived from their practical work and the ion stated in (f) to produce a balanced equation.

- Q2 The majority of candidates scored three marks for the weighings table; recording masses to at least 0.01g, using a mass in the specified range and completing the table with a correct subtraction. A small number of candidates recorded very strange figures for the mass of weighing bottle + residual **FA 3**. In these cases (and where the third line in the table was left blank) the examiners used the difference between the first two weighings in assessing accuracy.

The preparation instructions had specified -10 to $110^\circ \times 1^\circ$ thermometers. Following the guidance in the syllabus, already referred to, examiners were expecting to see temperature recorded to the nearest 0.5° C . One mark was given if all temperatures were recorded to one decimal place.

The temperature at $2\frac{1}{2}$ minutes was subtracted from the maximum temperature recorded in the table (ignoring any temperature reading at 3 minutes). The rise in temperature was divided by the mass of magnesium used to obtain $\Delta t.g^{-1}$. This was compared to the same ratio calculated from the supervisor's results. 5 marks were

given for a difference up to 4°, 4 marks for a difference between 4° and 8°, down to 1 mark for a difference between 16° and 20°.

Samples of magnesium provided varied greatly between centres. The examiners expected to see a $\Delta t.g^{-1}$ value of 60-70°. In some centres very little temperature rise was recorded and where the supervisor's value was $>35^{\circ}\text{C}$ the difference range for awarding marks was halved.

The majority of candidates scored 3-5 marks for accuracy.

The examiners checked the plotting of three representative points (2 min, 6½ min and 10 min if all points had been plotted). A number of candidates plotted a minimum of points, often insufficient to draw a graph of their results.

To gain the mark for the graph the candidates was required to draw an 'approximately' horizontal line up to the addition of the magnesium and a **best fit** curve or straight line for the cooling period of the experiment. Many candidates joined point to point.

Relatively few candidates understood the instruction to extrapolate the graph to estimate the temperature of the mixture at 3 minutes. (A very large number of Candidates drew a straight line between the temperatures at 2½ and 3½ minutes and recorded the temperature from this line at 3 minutes). A similar question to this was set in May 1996 when extrapolation was expected but no instruction to extrapolate given. The examiners had hoped to give an indication of what was required by including the instruction to extrapolate in this examination. This is a standard technique for determining a temperature rise but clearly one with which the majority of candidates are unfamiliar.

The calculation in (e) was performed by nearly all candidates but again a number used 24 rather than 24.3 for the relative atomic mass.

In (f) many candidates used the mass of magnesium or (50 + the mass of magnesium) in their calculation. Others multiplied only two of mass, 4.3 or Δt .

The majority of candidates obtained 1 mark in (g) for dividing their answer to (f) by their answer to (e). The second mark was only given if at least three significant figures, the correct sign and the correct units were shown in the answer.

In the **Evaluation of the Experiment** the examiners were looking for the major reasons for errors in the enthalpy change and simple modifications to the technique.

Marks (to a maximum of 6) were given for:

Loss of heat

Thermometers graduated to only 1°C

Unused magnesium – on the sides of the plastic cup after reaction – or material lost from the cup during the reaction.

Oxidation of Mg sample

Better insulation of the plastic cup

Using a thermometer graduated at 0.1°C or 0.2°C

Covering the cup to prevent loss of material

Using a fresh supply of magnesium powder.

Q3 The examiners were disappointed by the performance in the Observation and Deduction section of this question. **Candidates were reminded that a test in which there appears to be no reaction can, in fact, lead to a definite deduction.** The expected observations and deductions for ions in the list are based on the Qualitative Analysis Notes provided.

In (a), no observable reaction with hydrochloric acid (no gas produced) should have lead to a deduction of the **absence** of carbonate, sulphite or nitrite. No precipitate should have produced a deduction of Pb^{2+} **absent**.

No precipitate with barium chloride should then have drawn the single deduction of sulphate **absent**.

In (b), the majority of candidates recorded a white precipitate with silver nitrate but not all found the precipitate completely soluble in ammonia solution. Both observations were needed to gain the deduction mark of chloride present.

Candidates needed to record a white precipitate, insoluble in excess sodium hydroxide, in (c) to obtain the observation mark. This could lead to a deduction of Mg^{2+} or Ca^{2+} (Ba^{2+} ignored).

Many candidates recorded a precipitate in (d) where none should have been seen enabling Mg^{2+} to be eliminated.

In (e) the only mark given was for a correct observation, the other box having been shaded to indicate no deduction was required. The examiners were expecting an orange or red solution – not a red-brown colour and certainly no precipitate.

The majority of candidates recorded blue litmus turning red in (f). Some noted a pungent smell but did not recognise the smell of carboxylic acid. An observation mark was given to those who observed a smell of vinegar.

Many recorded the white precipitate with sulphuric acid but few related this observation to a cation with an insoluble sulphate (Ca^{2+} , Ba^{2+} , Pb^{2+}).

It was very disappointing in (g) to see that the majority of candidates did not recognise these instructions as those for the preparation of an ester. It is some time since an organic substance has been set in the Observation and Deduction section and candidates were clearly directing their thoughts to Inorganic possibilities as very few realised that the second anion was Organic in nature.

The smell of the ester was missed by the majority of candidates in this test. A white precipitate was again recorded by many, but no deduction made from this observation.

In the summary, many candidates obtained the first mark for Ca^{2+} and Cl^- but few gained the second mark for the salt of a carboxylic acid.

There were 17 marking points available giving a maximum of 15 marks for the section. It is customary to cancel marks in excess of 15 for a significant number of candidates in each session. In this examination only a very small number of candidates approached or exceeded the 15 mark maximum.

Assessment of Planning Skills

Once again this section proved to be difficult for a large number of candidates. Answers ranged from those who wrote short and precise plans that worked perfectly – quickly identifying the ions present in the solutions – to those who wrote a lot and found little and to those who wrote little beyond the first test which was given.

The problem posed was similar to that used in recent papers with the exception that the first step in the series of test-tube experiments was given to 'point the way'.

The instructions on page 12 told candidates that their plan should refer only to named chemicals and not to FA codes. Unfortunately, many candidates still appear to attempt this question by mixing solutions step by step and recording results rather than devising a plan which they carry out and whose results they record on page 13.

Marks were not given on page 12 when FA codes were used, but the examiners tried to piece together what had been done on page 13 to give credit for correct working.

Where, in the plan, candidates suggested incorrect chemistry in identifying an ion they were given credit for correctly using that ion in subsequent steps of their plan.

The examiners expected candidates to state that the solution containing Ba^{2+} would give a yellow precipitate or that containing Al^{3+} would turn the chromate solution from yellow to orange.

Those who identified Ba^{2+} added this solution to the remaining solutions – a white precipitate with two solutions revealing the sulphates. One of these, added to the remaining two solutions, would give a white precipitate with the NaOH and no precipitate with the Zn^{2+} . Addition of NaOH to the two sulphates would give a white precipitate in each case, but the solubility of the precipitate in excess NaOH would distinguish Al^{3+} from Mg^{2+} .

Where the NaOH had absorbed carbon dioxide from the air, three white precipitates could be seen on addition of the barium chloride. Some candidates were able to say that a slight precipitate identified the sodium hydroxide, the two heavy precipitates being the sulphates.

Where all three white precipitates were heavy, the solution containing Zn^{2+} showed no reaction and this could be used to identify the sodium hydroxide, the sodium hydroxide to find the aluminium sulphate and the aluminium sulphate to find the barium chloride.

Those who identified Al^{3+} in the first test could use this to identify both the barium chloride and the sodium hydroxide. This then enabled the remaining zinc nitrate and magnesium sulphate to be quickly identified.

10 marks were available for this section. 4-6 marks were common, 9-10 marks scored by a number of the more able candidates.

9254/07 Chemistry – Extended Investigations

General Comments

This paper is an alternative to the internal assessment of separate skills and, once again, the moderators continue to be impressed by the wide range of interesting and challenging investigations submitted by candidates. There is no doubt that candidates often derive considerable benefit from such investigations and it is clear that much of the success of the experience is due to the enthusiasm and hard work with which teachers have obviously supported their candidates.

The work of the moderators was made easier by full documentation supplied by most centres with candidates' work, and this was greatly appreciated. A few centres still fail to include the original approval forms with candidates' work. These forms are important since they often provide evidence of a candidate modifying an original idea in the light of practical experience. The choice of an investigation from the titles included in the *Teachers' Handbook* is not a guarantee that a given investigation will necessarily satisfy the criteria for all of the sub-skills. Furthermore, even if the moderator has approved an investigation, this merely indicates that the description submitted has the *potential* to satisfy criteria for all of the sub-skills, and does not imply that a given investigation will necessarily meet these in full.

The moderators were pleased to see that the vast majority of work submitted was of A-level standard, with few pieces of work falling short of this requirement. There were, once again, a small number of investigations which consisted of the same, relatively simple, practical task being repeated over and over, which severely limited the range of manipulative skills which the candidate could demonstrate.

The moderation process revealed that in general the candidates' work had been marked extremely thoroughly and at an appropriate level. Overall, the marks awarded for the investigations produced a reasonable spread, with some interesting investigations presented in an exemplary manner.

9254/09 Chemistry – Practical Assessment by Separate Skills

General Comments

Once again a large number of centres chose to assess their students' practical skills by internal assessment and it was encouraging that the vast majority of the work seen used appropriate experiments accompanied by clear assessment criteria. An improving feature was the helpful annotation of the candidates' work which greatly aided the understanding that must exist between the centres and the external moderators. There was often an understandable dependence on the available exemplar material but it was gratifying to encounter a wide range of other experiments judged more appropriate to the circumstances of an individual Centre. Two key issues must however always be addressed when choosing suitable practical work for assessment. Firstly, experiments must be of a fully appropriate A level standard and secondly, all work must be able to provide acceptable evidence for the evaluation of all the sub-skills chosen.

Both of the above provisos did occasionally cause the moderators concern. It is very difficult to be fair to the candidates if an experiment used is so undemanding that all students readily achieve level 2 on all sub-skills. This, in the extreme, can lead to an excessive use of top marks without the necessary supporting evidence. It is expected, for example, that skill C should involve quantitative work requiring some careful processing by the student. It is not sufficient to calculate the percentage yield of a product or deduce the identity of a single ion as a result of some simple tests. Likewise the indiscriminate listing of a wide range of potential improvements to a procedure does not constitute the reasoned analysis of the significant errors expected for sub-skill C3. Equally the desire to extend a perfectly sound practical to embrace sub-skills which cannot be supported leads to inflated marks. A common example of the latter was the use of an organic preparation which is excellent for skills B1 – B3 but dubious for B4 and B5.

Generally centres provided planning exercises which did not guide the student too obviously but this still remains a potential weakness in some cases. It is understood that, since the approach of some students may be unexpected, marking schemes for skill A may have to be more flexible than for the other skills. The moderators do, however, particularly value a clear explanation of how the marks have been ascertained where the candidate has followed an unusual path.

Centres should also be aware of a further continuing concern. Marking schemes should always include a penalty for students who fail to record measurements to an appropriate level of accuracy. For example, all titration readings should include the appropriate number of decimal places – including an initial reading that happened to be zero. Likewise the processing of data should lead to an answer which, in its use of significant figures, relates to an accuracy that could be realistically be achieved. A common failing, too often ignored by Centres, was the quotation of the result, sometimes containing several decimal places, of an enthalpy calculation based on an experiment of modest accuracy with measurements which had been multiplied by a large factor to obtain a value per mol

9434 Chemistry: Special Paper

General Comments

This paper is very demanding and requires considerable preparation from candidates. Entrants are always strongly advised to do as many old S-level Papers they can, and to extend their perceptions, knowledge and understanding of Chemistry as they do so. A mark of around 12/20 per question will lead to an A, around 10/20 to a B.

Comments on Individual Questions

Question 1

A popular question. Hydrogen bonds are unique to hydrogen since the atom is so small and has a non-directional s electron only. It is formed with $\text{H}-\text{X}\cdots\cdots\text{H}-\text{X}$ where X is the most electronegative elements only – F, O, N. The expected answers are given in the mark scheme, but many candidates failed to use water as their example in (c) to explain the intermolecular forces in the sequence ice-water-water vapour and that on melting the molecules are still adjacent although free to move. Only a few of the hydrogen bonds are broken when ice melts.

Question 2

A popular question for candidates who were able at algebra. It was a high scoring question for such talents. In (a)(i), the partial pressures of each of the three gases has to be calculated. In (c), the gases are not under ideal conditions and the volume occupied by the molecules themselves (about 1 in a thousand at 1 atm.) will be considerable at 200 atm. The space (volume) is considerably less than expected so less ammonia is expected at equilibrium than from the K_p expression.

Question 3

The least popular question but an interesting one. The few candidates who tackled this question scored good marks. The subject material demanded prior study and understanding. The mark scheme should be referred to.

Question 4

A popular question. The equation $2\text{IF}_3 \rightarrow \text{IF}_5 + \text{IF}$ was common, and explains the disproportionation involved. IF_5 does not utilise all the electrons of the iodine atom and the lone pair explains its permanent dipole. The answers to (b) are given in the mark scheme. Candidates went wrong in the calculation for E and did not realise that the missing 6.2 % is NH_4^+ .

Question 5

Another popular question. There are 12 marks given for the five examples in (a) so that 2 or 3 marks are given for each. Hence candidates are expected to extend their answers. Too often candidates answered along the right lines but with insufficient depth. The mark scheme indicates how the depth could be achieved.

Many candidates scored full marks in (c)(ii) with simple but complete explanations why the second mechanism had to be supported.

Question 6

A popular question. In (a) there has to be an unpaired electron for a species to show paramagnetism. It was not uncommon to suggest that N_2O_4 is paramagnetic but it contains the N-N bond. The rest of the question is straightforward for this level.

Question 7

Candidates needed to plan their answers so that these were intelligently extended with explanations to gather the four marks allocated to each section. In (a)(iii) the formation of ethane required the free radical mechanism which crops up in the reaction of methane and chlorine in UV light. The loss of the electron from $CH_3CO_2^-$ at the anode gives a free radical.

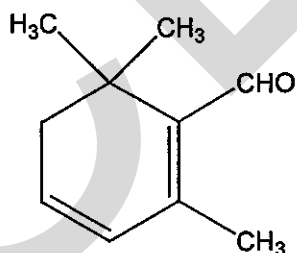
Question 8

The mark scheme shows how the 16 marks of (a) were allocated. A quick method of analysis would score higher than a longer one which involves several stages. To illustrate this, in (iii) heating with NaOH (aq) hydrolyses the first amide to ammonia, easily recognised. Candidates do not need to identify, but only name, the phenylamine produced from the second amide. Not all the successful methods of identification are included in the mark scheme; inevitably there are other successful methods. Candidates at this level show commendable inventiveness.

Question 9

This is acknowledged to be a brute of a question. If the structure of the saffron yellow pigment, P, is looked at in the mark scheme, one can see how difficult its elucidation by traditional organic analysis will be. However, on the question paper, the examiners have stated that high marks can be scored without a complete structure for P being obtained.

P is



12 marks can be obtained explaining the reactions described in (a). Y can be deduced from the substituted cyclobutene in the question paper. Note also that four structures were allowed for P. It is necessary that good candidates recognise that both secondary and tertiary alcohols are formed by careful oxidation of the alkene groups and that only the secondary alcohols are oxidised to ketones.

Part (b) was marked by the principles involved. A molecule with x chiral centres has 2^x stereoisomers.

CAMBRIDGE LINEAR A LEVEL CHEMISTRY 9254
JUNE 2000 ASSESSMENT SESSION

Component Threshold Marks

| Component | Maximum Mark | A | B | C | D | E | N | U |
|-----------|--------------|----|----|----|----|----|----|---|
| 1 | 72 | 54 | 48 | 41 | 35 | 28 | 22 | 0 |
| 2 | 48 | 39 | 34 | 30 | 26 | 23 | 20 | 0 |
| 3 | 40 | 30 | 26 | 24 | 22 | 19 | 17 | 0 |
| 4 | 40 | 29 | 26 | 23 | 20 | 17 | 14 | 0 |
| 5 | 75 | 54 | 49 | 45 | 41 | 37 | 33 | 0 |
| 7 | 36 | 33 | 29 | 26 | 23 | 20 | 17 | 0 |
| 9 | 36 | 34 | 31 | 28 | 25 | 22 | 19 | 0 |

Overall Threshold marks

| Option (components) | Maximum Mark | A | B | C | D | E | N | U |
|---------------------|--------------|-----|-----|-----|-----|-----|-----|---|
| A (1, 2, 3, 4, 5) | 250 | 183 | 163 | 148 | 130 | 112 | 95 | 0 |
| C (1, 2, 3, 4, 7) | 248 | 194 | 173 | 153 | 134 | 114 | 95 | 0 |
| D (1, 2, 3, 4, 9) | 248 | 194 | 174 | 154 | 136 | 121 | 104 | 0 |

The cumulative percentage of candidates achieving each grade was as follows:

| Grade | A | B | C | D | E | N | U |
|------------------------------|------|------|------|------|------|------|-----|
| Cumulative percentage | 27.6 | 47.2 | 63.3 | 75.3 | 86.3 | 94.2 | 100 |
| Number of candidates | 260 | 185 | 152 | 113 | 104 | 74 | 55 |

Chemistry Special Paper, 9434

| Maximum Mark | Distinction | Merit | Unclassified |
|--------------|-------------|-------|--------------|
| 100 | 56 | 43 | 0 |

The cumulative percentage of candidates achieving each grade was as follows:

| Grade | Distinction | Merit | Unclassified |
|------------------------------|-------------|-------|--------------|
| Cumulative percentage | 33.9 | 62.9 | 100 |
| Number of candidates | 21 | 18 | 23 |