CHEMISTRY

Paper 9701/12
Paper 1 Multiple Choice

Question Number	Key	Question Number	Key	Question Number	Key	Question Number	Key
1	D	11	A	21	C	31	D
2	C	12	C	22	C	32	A
3	D	13	A	23	D	33	D
4	D	14	D	24	C	34	A
5	C	15	A	25	B	35	C
6	B	16	A	26	D	36	A
7	D	17	C	27	B	37	D
8	C	18	C	28	D	38	B
9	B	19	D	29	D	39	C
10	C	20	B	30	D	40	C

General comments

This examination paper provided a suitable challenge to the candidates. The statistics for individual questions suggest that candidates had sufficient time to complete the paper.

Seven questions were found to be easier. The majority of candidates chose the correct response to each of **Questions 1**, **3**, **5**, **7**, **15**, **24** and **34**. Five questions were found to be particularly difficult. A minority chose the correct response to each of **Questions 9**, **22**, **25**, **27** and **33**.

The questions that were found to be particularly difficult will now be looked at in greater detail.

Question 9

A minority of candidates chose the correct answer, **B**. The most commonly chosen incorrect option was **D**. Option **D** is incorrect because the expression given does not have twice the enthalpy of formation for each substance. Therefore, the expression given will calculate the enthalpy change for the combustion of one mole of C_2H_6; the equation in the question has two moles of C_2H_6. The expression in option **B** will calculate the enthalpy change for the combustion of two moles of C_2H_6.

Question 13

Due to an issue with this question, it was discounted. Each candidate's total mark was multiplied by a weighting factor so the maximum mark for the paper remains unchanged.

© 2024

Question 14

Due to a series-specific issue during the live exam series, this question was discounted. Each candidate's total mark was multiplied by a weighting factor so the maximum mark for the paper remains unchanged.

Question 22

A minority of candidates chose the correct answer, **C**. The most commonly chosen incorrect option was **A**. The majority of candidates knew that $Ca(NO_3)_2$ decomposes at a lower temperature than $Ca(NO_3)_2$. The correct colour change is green to red, as NO_2 is acidic.

Question 25

A minority of candidates chose the correct answer, **B**. The most commonly chosen incorrect option was **D**. The majority of candidates knew that the six membered rings in cholesterol are not planar. Cholesterol does not show cis/trans isomerism at the double bond. The C=C bond is part of a six membered ring. This means the other isomer cannot exist without making structural changes.

Question 27

A minority of candidates chose the correct answer, **B**. The most commonly chosen incorrect answer was option **D**. The majority of candidates knew that the product of the reaction between but-2-ene and cold dilute acidified $KMnO_4$ does not have an aldehyde or a ketone group. Product Y is ethanoic acid so does not have an aldehyde or a ketone group, so the answer to this question is **B**.

Question 33

A minority of candidates chose the correct answer, **D**. The most commonly chosen incorrect answer was option **A**. The other options were equally chosen.

- Option **A** – both compounds will give a yellow solid with alkaline I_2(aq), therefore they give the same visible result.
- Option **B** – both compounds will give a yellow solid with alkaline I_2(aq), therefore they give the same visible result.
- Option **C** – neither compound reacts with alkaline I_2(aq) to give a yellow solid, therefore they give the same visible result.
- Option **D** – ethanol reacts with alkaline I_2(aq) to give a yellow solid but propanal does not. Therefore, they give a different visible result.

© 2024

www.dynamicpapers.com

CHEMISTRY

Paper 9701/22
Paper 2 AS Level Structured Questions

Key messages

Structured questions give candidates the opportunity to show their knowledge and understanding over a wide range of syllabus topics. The best answers are concise and precise: there is often little need for fully developed sentences, providing that the sense and balance of answers are clear. The accurate use of chemical terminology remains crucial to remove ambiguity from responses; there is often little need to paraphrase.

Candidates are reminded to address 'explain' questions fully by not merely stating facts or rules of thumb, but to show how these combine to give reasons for chemical phenomena. This often requires a secure understanding of bonding and structure within molecules, in particular for organic species, linking structural feature to mechanistic probabilities.

Working in the calculation questions should be shown to ensure that due credit can be awarded, especially where a numerical answer might be obtained by different methods, correctly or incorrectly. Harsh or early rounding of numbers should be avoided, as it leads to sizable inaccuracies later.

General comments

This paper tested candidates' knowledge and understanding of important aspects of AS Level Chemistry. Candidates showed themselves able to perform well in both AO1 and AO2 items, though there were some notable weaknesses.

Where candidates find it necessary to write at greater length than the space provides, they are advised to give a clear indication of where their continued writing can be found. Diagrams should be labelled as fully as possible, to avoid ambiguity or conflict with more extended writing.

Comments on specific questions

Question 1

This was a broad-based question, encompassing ideas of physical, inorganic and organic chemistry. Candidates were adept with simple definitions, but application of ideas showed some deficit of understanding.

(a) Many diagrams were well presented, but a substantial number neglected to label the particles: mention of delocalisation of electrons was crucial. A sizable minority incorrectly identified the positive particles as protons or nuclei.

(b) (i) This question was mostly well answered, though errors of balancing and 'Bi_2' were often seen.

(ii) Although many candidates secured full credit here, common errors were not to link deduction and reasoning (e.g. giant *because* high melting point) and to offer contradictory statements (e.g. giant molecular and ionic bonding). In many cases, brevity served better. Some candidates appeared confused about the compound they were being asked to describe, Bi_2O_3, rather than bismuth itself.

© 2024

(c) (i) This was answered well, though answers of +6 were commonly seen with respect to bismuth.

(ii) Many different answers were offered here, including $NaBH_4$ and O_2, whereas candidates needed to refer to a compound given in the equation.

(d) (i) This was generally well answered. It is preferable to refer to transfer of electrons when explaining the term oxidising agent.

(ii) Some contradictions were observed here, such as 'cold dilute … heat under reflux.'

(iii) Many candidates answered this well. Common errors included a switch of answers in the case of Tollens' reagent and neglecting to mention a precipitate or solid in the iodoform and DNPH reactions.

(iv) Many candidates tried unsuccessfully to include $NaBH_4$ in their answers. Candidates are reminded that even with the use of [H], there is a need for a stoichiometric balancing number. Use of CH_3COH is discouraged as a method of representing aldehydes.

(e) The initial stages of most calculations were good, but many candidates then forgot to multiply by 40 (to scale up to 1 dm^3 from 25 cm^3) or to multiply the concentration by 10 (1000 ÷ 100). In general, working needed to be shown more clearly, as some inventive methods could otherwise have given a seemingly correct answer.

Question 2

This was a holistic question based around the chemistry of chlorine and chlorides. Candidates are recommended to give brief answers to one-mark questions and to draw diagrams clearly.

(a) Common errors were found in the formulae of the chlorides, the structure of $SiCl_4$ and in the pH of a $NaCl$ solution (neutral so pH 7; candidates often seemed to think that:
$NaCl + H_2O \rightarrow HCl + NaOH$).

(b) (i) Many variant and phonetic spellings of 'disproportionation' were observed.

(ii) There was an issue with this question in that water was not included as one of the products of the reaction, so full marks were awarded to all candidates to make sure no candidates were disadvantaged. This has been corrected in the published version of the paper.

(iii) This equation was rarely constructed correctly: where more valid attempts were made, common errors were either that $NaClO$ was given as the oxidation product or that the correct stoichiometric coefficients were omitted.

(iv) This was answered well by most candidates, although a number offered effervescence as an observation.

(c) (i) Octahedral was the most common answer for PCl_6^-, although commonly hexagonal or octagonal were seen (and not credited). A broad range of answers were given for PCl_4^+, with 'trigonal pyramidal' (missing the bi- prefix) and 'bipyramidal' (missing the base shape) among them.

(ii) **J** was often correctly identified as H_2O/water. Hydration or displacement were often given instead of hydrolysis or substitution for the type of reaction.

(d) (i) Some very loosely drawn diagrams were unable to be given full credit: curly arrows should come from a clear origin (the middle of a bond, or from pair of electrons, rather than a negative charge) and, in cases such as this, the arrowhead needs to have both 'blades' and point to a specific atom or the middle of a bond.

Many candidates also confused partial charges/dipoles with full formal charges.

(ii) Candidates were required to reference heating the ethanolic NaOH to gain full credit.

© 2024

(iii) Many answers retained the C=C or arranged the 3C monomer linearly with no branching. These were both common and recurring errors in questions of this type.

Question 3

This question tested candidates' abilities to apply their knowledge in slightly unfamiliar contexts. In-depth knowledge and recall of nitrogen chemistry was crucial, as was the ability to draw clear, labelled, unambiguous diagrams.

(a) Different types of answer were needed to gain full credit. A strong triple bond and high E_a are in effect making the same point.

(b) (i) There were many correct answers here, with balancing being the main difficulty.

(ii) Very few answers correctly referenced both acidic species, HNO_3 and HNO_2. The latter was rarely seen.

(iii) Candidates deployed a full range of answers referring to environmental issues: specifically, this was looking at photochemical smog.

(c) (i) Candidates found it challenging to apply the definition of standard enthalpy change of formation; attempting to conceive of two numbers that would sum to –46 (or –92), or that combined with the ΔH_f would sum to zero.

(ii) Many candidates were able to give good definitions here.

(iii) Candidates did not perform well on this question. Despite '**rate**' being in bold in the question, the large majority of responses attempted to answer in terms of yield and equilibrium position. Nevertheless, some credit was available for correct and non-contradicted information about a decrease in rate. Where collision theory is referenced, candidates are reminded of the need to discuss the *frequency* (i.e., number *per unit time*) of collisions, rather than simply the number.

(d) (i) Many diagrams showed a triple bond between the nitrogen atoms or miscounted the number of non-bonding electrons.

(ii) Candidates did not show a good understanding of hybridisation as responses divided reasonably equally between those who offered sp, sp^2 and sp^3 as answers.

(iii) Some good answers were seen here, but many answers could not be awarded full credit. *Sideways* overlap of p orbitals was needed in the response, or a clear and labelled diagram showing this as part of an unambiguous representation of a pi bond.

Question 4

This an organic and spectroscopic question. Candidates are advised to be clear in matters of structure, both when representing molecules diagrammatically and when referring to features within a molecule, such as those identified by different types of spectra.

(a) This was answered well by many candidates. There were incidences of ambiguous answers, such as a 'crossed tick' (✓✗). Credit cannot be awarded if an answer is ambiguous.

(b) (i) Unambiguous structural formulae only were accepted, therefore molecular formulae were discounted and those in which the connectivity was questionable.

(ii) There were many correct answers to this question.

(iii) This proved to be one of the most challenging questions on the paper, requiring the balanced inclusion of (2)H_2O and H^+ on the left-hand side, and NH_4^+ on the right. Salts from viable reactions of specific acids were accepted.

(c) (i) Candidates who understood the $M^+ : [M+1]^+$ ratio were generally able to gain full credit here. Occasional arithmetical errors were seen.

© 2024

(ii) Many candidates gave 'ester' as a correct answer but were then unable to corroborate this with sufficient and necessary information from the spectrum. Reference to an absorption outside of the C=O ester region contradicted an answer; equally, an absorption within the 1710–1750 cm^{-1} window was not solely sufficient, because of overlap with other absorptions. Corroboration could be given with reference to the C–O stretch (and the lack of O–H stretch).

C–H stretches are always ignored in these situations.

Absorptions must be accompanied by with assignment to an identified bond.

(iii) Propan-1-ol was a common incorrect answer for **T**. OH– is discouraged as a representation of an alcohol group. Many candidates did not draw the branched C5 acid correctly: some structures were unbranched; others had too many or too few H atoms.

© 2024

www.dynamicpapers.com

CHEMISTRY

Paper 9701/33
Paper 3 Advanced Practical Skills 1

Key messages

- Candidates should refer to the information and instructions given in the question to ensure they record all data required.
- Candidates should display their working to calculations clearly and use the data values given in the paper.
- Candidates should be encouraged to use concise, correct terminology when describing their observations.
- Candidates should read the stem of each question carefully because it may contain information needed to correctly answer later question parts.
- Supervisors should carry out and record all practical parts of the qualitative analysis question as well as all the practical parts of the quantitative analysis questions as given in the Confidential Instructions.

General comments

This paper generated a wide range of marks with few candidates unable to complete the tasks set. Better performing candidates made good use of previous principal examiner reports, past question papers and mark schemes in their preparation for examinations. Some candidates made their scripts difficult to read by writing their results in light pencil instead of using black or dark blue ink or by writing one number on top of another. This makes it difficult to determine the intended answer. A few centres were unable to access copper(I) oxide but examiners were able to adapt the mark scheme for those centres highlighting the problem in the supervisor's report so that the candidates were not penalised.

Centres should note that blank copies of the insert do not need to be returned with the examination papers.

Comments on specific questions

Question 1

Most candidates gained at least half the marks available for this question. Graphing skills appear to be improving. However, greater depth of response in the latter parts of the question was needed from many.

(a) Candidates should read the instructions in the method carefully before starting. Most wrote their results table on page 4 as instructed but some candidates wrote the table on page 3 then copied it onto page 4, which is a waste of time. Many candidates performed well for this question part. Some candidates did not give the correct unit for rate (s^{-1}) and many did not record their data with the appropriate precision. Candidates should consider the precision of apparatus used when recording their results. Many either gave their volumes of **FA 1** and distilled water to an integer or one decimal place or gave time to a fraction of a second; '39.0 s' is not recording time to one second. One of the most important issues was that not all candidates realised that there should be a constant total volume for this procedure to be valid. Many candidates gained some credit for the accuracy of their recorded results.

© 2024

(b) Almost all candidates labelled the axes of the graph. However, there was a significant minority who ignored the instruction that the origin should not be included in their scales so did not use at least half the grid in both the *x* and *y* directions. Candidates should be encouraged to use scales based on 1, 2, 4 or 5. Those who chose difficult scales invariably made errors due to mis-plotting. A line of best fit should be a continuous straight line or curve with points balanced either side, no rotation of the line possible and any anomaly clearly marked. Some candidates were more adept at this than others.

(c) 'Show clearly **on the grid**' necessitated a minimum of marking the *x*- and *y*-axes at the appropriate points and where a vertical line from the *x*-axis would meet the line of best fit. Better performing candidates included the appropriate vertical and horizontal lines on their graphs. Some candidates did not convert the rate from the *y*-axis to a time. However, many candidates were able to correctly determine the reaction time and also show clearly how they did this on the grid.

(d) Some candidates did not understand that there should be no residue from the previous experiment if the beaker has been rinsed with water. Some did not answer the question as they suggested time would be 'affected' or 'inaccurate' or only referred to rate. 'Time is slower' is a scientifically incorrect response. Stating 'the time would be longer as water remained' is correct but insufficient as an explanation. Better performing candidates correctly explained that dilution or reduced concentration of the reaction mixture required a longer time for the insert to become invisible.

(e) (i) The majority of candidates correctly stated the student was correct. However, far fewer connected this to the decreased depth of mixture (caused by the greater cross-sectional area of the beaker). Many appeared confused by the ideas of surface area and rate of reaction.

(ii) Fewer candidates stated the student was incorrect. Candidates may not have understood the significance of the word 'relative' not preceding 'rate'. Of those who stated the rate of production of sulfur would not change, only some went on to explain that this was owing to the concentrations of the solutions being the same.

Question 2

The Quantitative analysis instructions state that candidates should read through the whole method before starting any practical work and prepare a table for their results. Acting on this advice would have benefitted some candidates.

(a) Candidates should always use the same balance for their readings. This means that balance readings will always be to the same number of decimal places. Two decimal place balances are specified in the syllabus and are adequate for work at this level. A one decimal place balance will not be acceptable for this syllabus from 2025. As thermometers are calibrated at 1 °C, all readings should be to .0 or .5 °C. Many candidates gave their thermometer readings as integers. Some also incorrectly used 'weight' in place of 'mass.' Some candidates omitted information, usually the change of temperature, from their tables. Most candidates were able to gain credit for accuracy.

(b) (i) Almost all candidates were aware of the equation $q = mc\Delta T$. However, many used the mass of **FA 4** and/or used 4.2 or 4.81 as the numerical value of *c*. Candidates should be reminded of the data section given at the end of the paper. A few candidates incorrectly added 273 to ΔT. Some did not give their final answer to an appropriate number of significant figures.

(ii) Many candidates determined which reactant was in excess. Errors included the use of 24 instead of 24.3 as the A_r of magnesium and the use of 159.6, the M_r of copper(II) sulphate, instead of the volume and concentration when calculating the amount of each reactant.

(iii) Errors were often seen in answers for this straightforward calculation. These included using the amount of the reagent in excess in their calculation, using the sum of the number of moles of **FA 3** and **FA 4** or giving the answer to more than four significant figures.

© 2024

(c) The majority of candidates focused on improving the method, usually by reducing heat loss. Only the better performing candidates answered in the way expected by changing the method such that the processing of results also changed. Centres should ensure that candidates have carried out, or seen a demonstration of, the basic experimental procedures that illustrate topics in the syllabus.

Question 3

A wide variety of marks were seen for this question, with most of the marks gained being in **(a)**. Some of the responses for this question were inadequate, e.g., 'cloudy solution', which is a contradiction. Some candidates did not act on the information given in the Qualitative analysis instructions and notes. Thinking about possible outcomes of tests before starting the practical work would have benefitted some candidates.

(a) In **Test 1**, purple aqueous acidified potassium manganate(VII) is added to a colourless solution. Candidates should clearly record any change in colour observed. Hence, for **FA 5**, 'stays colourless' is incorrect as it does not indicate that a reaction has taken place. '**FA 6** 'goes purple' incorrectly suggests a change, and therefore a reaction, has taken place which is incorrect. 'The potassium manganate(VII) stays purple' or 'no change' are correct observations in this case. Candidates in some centres reported brown precipitates in **Test 1**. This suggests that these centres did not supply an acidified solution. In **Test 2**, 'gas evolved' is not accepted as an observation because this is a conclusion from the observation of effervescence/bubbling/fizzing. Many candidates did not carry out a test to identify the gas given out. Some candidates used the wrong test, for example, use of limewater, litmus paper or a glowing splint. In **Test 3**, the formation of white or milky solution was sometimes reported, this is not a suitable description for white precipitate formed. Some candidates were unable to access marks for the white precipitates in **Test 3** as they went on to add acid (usually unnamed), which is contrary to the instruction that 'No additional tests should be attempted.'. Candidates should be reminded that 'no observation' is not synonymous with 'no change'.

(b) (i) Candidates are told at the start of **Question 3(a)** that the anion in each solution contains sulfur. It was common to see the anion in **FA 4** identified as nitrite. Nevertheless, many candidates gave sufficient correct observations in **(a)**. A few supplied an incorrect charge for an ion or gave the names instead of the formulae. Candidates should write the symbols for both sulfur and oxygen as capital letters.

(ii) Only the better performing candidates gained credit in this part. Whilst both sodium carbonate solution and litmus paper were supplied to candidates, the majority ignored the instruction to carry out 'a further test' and suggested the use of a lighted splint, which should have been carried out in **(a)**. Those using the sodium carbonate often did not go on to describe a white precipitate being formed by the resulting gas bubbling through limewater. Describing the limewater as turning milky or cloudy is not an acceptable alternative to the formation of a white precipitate.

(c) Few candidates wrote a correct ionic equation. The most common errors were inclusion of spectator ions, incorrect charges on ions, unbalanced equations and lack of state symbols.

(d) (i) A range of colours for the residue was allowed as the pink-brown may have been obscured by it being wet with blue solution. However, 'red' is a colour rarely seen in this type of practical exercise and so was not credited. There were some candidates who confused 'residue' with 'filtrate'.

(ii) There was a range of acceptable colours for the mixture. The instruction given was to record observations before filtering.

(iii) It was apparent that many candidates did not add a sufficient volume of aqueous sodium hydroxide to complete the expected observations. Candidates often reported a blue precipitate on the addition of sodium hydroxide; few noted that the precipitate was insoluble in excess.

© 2024

www.dynamicpapers.com

CHEMISTRY

Paper 9701/42
Paper 4 A Level Structured Questions

Key messages

- Candidates must ensure their handwriting is legible. Handwriting that is too small often becomes illegible.
- Candidates should never attempt to write over the top of a previous answer if they wish to change their answer. The original answer should be clearly crossed through and a new answer should be written in available space.
- Chemical equations, ionic equations and half-equations should always be balanced for substances and charge.
- In organic reaction mechanisms, the starting and finishing points of curly arrows are a key part in the description of the mechanisms. Curly arrows should always start in a precise place and should be pointing towards a precise place.

General comments

The paper enabled candidates to demonstrate their knowledge and understanding of a wide range of chemistry topics.

Many candidates were able to work through to the end of the paper, suggesting they had sufficient time.

Comments on specific questions

Question 1

(a) (i) This definition was well known.

(ii) This was found to be difficult. Many candidates gave an explanation in terms of lattice energy and hydration energy instead of entropy.

(b) (i) This question discriminated well. Most candidates stated that anion radius increases down the group. They often did not explain this effect in relation to the dipole-ion forces becoming weaker.

(ii) Most candidates answered this question well.

(iii) Candidates performed well on this question. A common error was –608 (omitting use of –293).

(iv) This was well answered. Some common errors were 1.92×10^{-3} (omitting 2 in their expression) and 1.53×10^{-3} (use of 2 instead of 4 in their expression).

(v) This was usually answered well. Some candidates did not clearly refer to the cationic radius, Pb^{2+} or K^{+}, and stated the ionic radius of PbI_2 instead.

(c) (i) Candidates performed well on this question.

(ii) This was generally well answered. Most of the candidates could recall and correctly use the Gibbs equation. Some converted their values to J mol^{-1} and omitted their units with the final answer (–50108.8 J mol^{-1}).

© 2024

(iii) Most candidates were well prepared for this type of question. Many gave a correct statement regarding increasing stability and increasing cationic radius down Group 2. The decrease in the polarisation of the carbonate anion was less frequently described. Some candidates incorrectly suggested there was polarisation of the cation or that polarisation was caused by the anion.

(d) (i) This proved difficult for candidates and they did not recognise that an aqueous solution was being electrolysed. The most common error was $K^+(aq) + e^- \rightarrow K(s)$.

(ii) Many candidates calculated the correct current used. Most correctly worked out the number of moles of $S_2O_3^{2-}$. The calculation of Q was found to be more challenging. Some common errors were 0.858 (omission of $\times$ 0.5) and 0.21 (omission of $\times$ 2).

(e) (i) This was generally well answered. The reagents and conditions for reaction 2 were better known than reaction 1. Common errors included use of HNO_2 or omitting 'concentrated' for reaction 1.

(ii) This question discriminated well. The equation for step 1 was usually correct. Candidates had difficulty constructing a balanced equation for the formation of $C_6H_5N_2^+$. Most of the incorrect answers for step 2 were not balanced in terms of atoms and/or charges.
For example:
$C_6H_5NH_2 + HNO_2 \rightarrow C_6H_5N_2^+ + 2H_2O$
$C_6H_5NH_2 + HNO_2 \rightarrow C_6H_5N_2^+ + H_3O^+$

(iii) This was generally well answered. Common errors included electrophilic substitution and addition elimination.

Question 2

(a) (i) This answer was usually correct.

(ii) This was generally answered well. Common errors were use of 'attract a proton' (instead of accept) and also some candidates did not make the connection between the lone pair on the nitrogen accepting the proton.

(iii) Most candidates answered this question well. A common error was the use of OH^- on the left-hand side: $CH_3COOH + OH^- \rightarrow H_2O + CH_3COO^-$

(b) (i) This expression was well known. A common error was the inclusion of $[H_2O]$.

(ii) This was generally well answered. A small minority incorrectly suggested that this was an exothermic process.

(iii) This proved difficult for some candidates. Better performing candidates were able to calculate $[OH^-]$ in the neutral solution at 30 °C, then state that $[OH^-]$ would be greater than $[H^+]$ at pH 7. Weaker responses suggested that as K_w has increased so the solution must be alkaline.

(c) (i) This was usually answered well. Many candidates suggested that the liquid particles have a more disordered arrangement that solid.

(ii) This was found to be challenging and typically candidates did not answer in terms of the relative difference in the arrangement of the particles in a gas as compared to a liquid. For example, the gas particles would have a much more disordered arrangement than the liquid particles.

(iii) Many were able to work out the temperature, which is close to 273K, typically showing a calculation for T when $\Delta G = 0$.

(d) (i) Candidates performed well on this question.

(ii) This discriminated well and some good answers were seen. Common errors included 0.754 (use of z = 1), 1.05 (use of $[OH^-] = 10^{-11}$) and 0.223 (use of $[OH^-] = 1000$).

© 2024

Question 3

(a) (i) Candidates performed reasonably well on this question. Some gave an incomplete answer and did not specify the type of orbitals.

(ii) This was generally answered well. Common errors included $3d^8$ (for Fe) and $4s^23d^3$ (for Fe^{3+}).

(b) (i) This definition was well known.

(ii) This answer was usually correct. A common error was 3.

(iii) This proved to be difficult; many decided it must be 90° as it is an octahedral complex.

(iv) Candidates performed well on this question. The splitting of d orbitals; the absorption of photons of visible light; the excitation of electrons and the observed colour being complementary to the colour absorbed were all described clearly. Some omitted the reason for the difference in colours of the complexes.

(v) This was generally answered well. Many candidates correctly identified ΔE would be different, so a different wavelength of light would be absorbed.

(c) (i) Candidates performed well on this question. A common error was using $H_2PO_4^-$ on the left-hand side: $[Fe(H_2O)_6]^{3+} + H_2PO_4^- \rightarrow [Fe(H_2O)_5(H_2PO_4)]^{2+} + H_2O$.

(ii) This was found to be difficult. Common errors included the charges of the concentration species outside (instead of inside as shown) their outer brackets. The units were more commonly correct.

$$K_{stab} = \frac{[[Fe(H_2O)_5(SCN)]^{2+}]}{[[Fe(H_2O)_6]^{3+}]\,[SCN^-]}$$

(iii) This answer was usually correct.

Question 4

(a) (i) This proved challenging for most candidates. A common error was **X** $[Ru(H_2O)_4Cl_2]^+$ and **Y** $[Ru(H_2O)_5Cl]^{2+}$.

(ii) Candidates performed well on this question. Most were able to draw one correct isomer.

(b) (i) This was generally answered well.

(ii) This question discriminated well. Common errors included omitting the term planar, incorrect hybridisation of N (sp^3) and insufficient explanation about how the pi bonds are formed (a p orbital from each atom overlaps sideways).

(iii) This was found to be difficult. Candidates who were able to recognise the symmetry in pyrazine performed well on this question. Other candidates incorrectly suggested that the molecule would have two or four peaks.

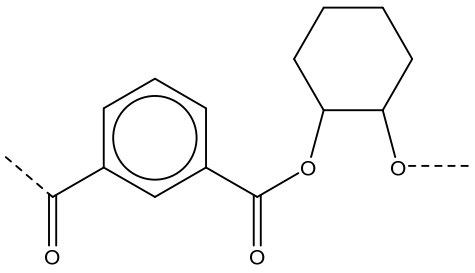
(iv) Candidates performed well on this question. Some misinterpreted the question and only gave one oxidation number.

(c) (i) This answer was usually correct. Common errors were HCl or $AlCl_3$.

© 2024

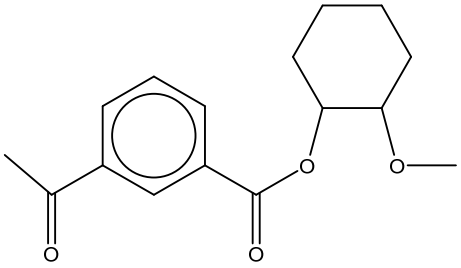
(ii) This question discriminated well. Many candidates were able to draw the correct ester linkage between the two monomers. Some candidates did not clearly show the continuation bonds (as structure **B**).

structure **A**



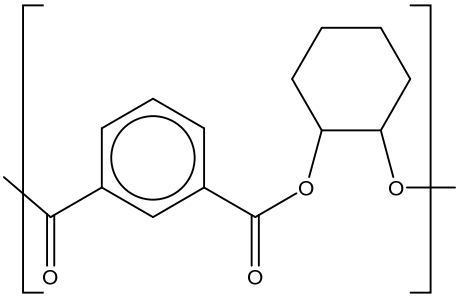
two marks correct

structure **B**



just one mark (M1)

structure **C**



two marks correct

Question 5

(a) (i) Candidates performed well on this question. Some incorrectly used Cl_2 instead of CH_3Cl in their equation.

(ii) Those who had understood well the electrophilic substitution mechanism found this to be accessible.
Common errors included:
- the curly arrow in step 1 was sometimes omitted.
- an incorrect structure of the intermediate – the partly delocalised ring should not include the sp^3 carbon and positive charge should not be on the sp^3 carbon.
- the curly arrow in the intermediate starting on the H not on the C-H bond.
- HCl formed instead of H^+ ion at the end of the mechanism.

(iii) This question discriminated well. A common error was: $C_6H_4(Cl)CH_3 + [O] \rightarrow C_6H_4(Cl)CHO + H_2$.

(iv) This proved difficult for some candidates. Common errors were for step 3, KCN in ethanol (omitting HCN) and for step 4, omitting 'aqueous' conditions or the use of concentrated H_2SO_4.

(v) This answer was usually correct.

(vi) Many candidates realised that NaOH(aq) would hydrolyse the ester bond.

(vii) This definition was well known. Some omitted the 'plane' of polarised light would be rotated.

(viii) This question was well answered.

(b) (i) Candidates performed well on this question. Common errors included 3.94 (transcription error), 3.44 (no × 10) and 1.44 (no ÷ 1000 mass).

(ii) This was well answered.

© 2024

www.dynamicpapers.com

Question 6

(a) (i) Many candidates answered this correctly. A common error was omission of pH in their definition.

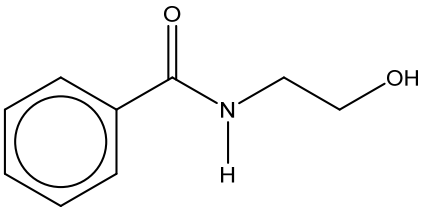
(ii) Most candidates gave the correct structure of glycine at pH 4.

(b) (i) This was not well known. Many omitted the need for heating in a sealed tube/under pressure.

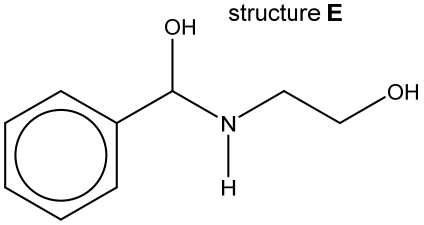
(ii) This was rarely awarded. Benzoic acid was the most common incorrect answer.

(iii) Candidates found this difficult. They had to recognise that the carboxylic acid group would be reduced to the corresponding primary alcohol and the amide to an amine. Some common errors are shown.

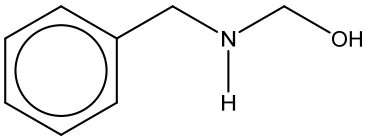
structure **D**



structure **E**



structure **F**



(iv) Most candidates answered this question well.

(c) (i) Candidates found this question challenging. Only a small number suggested that the nitrogen lone pair was delocalised into the C=O. However, candidates seemed more successful describing the subsequent effect of the amide lone pair being less available to accept a proton.

(ii) This discriminated well. Some good and clear answers were seen. The idea of the electronegative Cl was well known but some did not explain in terms of the strength of the O–H bond or the stability of the conjugate base. A common error was stating chloroethanoic acid is more acidic instead of a stronger acid than ethanoic acid.

(d) (i) This question discriminated well. Many good answers were seen. The chemical shift value for protons **c** and **d** were found to be the most difficult; the common error was 0.9–1.7. Candidates performed better on naming the splitting pattern than identifying the chemical shift range.

(ii) Many candidates answered this well.

© 2024

www.dynamicpapers.com

CHEMISTRY

Paper 9701/52

Paper 5 Planning, Analysis and Evaluation

Key messages

- Candidates are advised to clearly show their points by using a diagonal cross, 'x', with the intersect of the lines being the exact co-ordinates on the grid. Alternatively, a point within a circle, ⊙, would be suitable with the point being the exact co-ordinates on the grid. Candidates should be aware that a single point (with no circle) will likely not show up if a line of best fit needs to be drawn over it.

- In calculation work, candidates should be encouraged to show full working and in multi-step calculations, avoid early rounding as this invariably produces an incorrect final answer.

General comments

Candidates in general seemed more aware of practical procedures than in recent years, possibly as a result of centres being able to offer more practical work post-Covid.

Nearly all candidates completed the questions and there were very few omitted questions.

Candidates should be aware of the need to use an appropriate number of significant figures in numerical answers, even when a question does not specify an exact number of significant figures. One significant figure will usually be insufficient at A Level.

Comments on specific questions

Question 1

(a) Most candidates knew that the order of the two key readings were firstly the mass of the weighing boat with solid silver nitrate in it, followed by mass of the weighing boat after transfer of the silver nitrate. This means that the true mass of silver nitrate transferred is known and allows for any residual deposits left behind on the weighing boat after transfer.

Many did not understand the meaning of weighing by difference and assumed this was weighing an empty boat followed by weighing the combined mass of the weighing boat and silver nitrate.

Nearly all candidates constructed a suitable table, although many did not include units of mass i.e., 'g'. At A Level, the term 'mass' is expected rather than the term 'weight'.

(b) Candidates are becoming more competent at describing how to make up a standard solution from a solid in a beaker, but they do need to read the question carefully. The solid silver nitrate was in a 100 cm^3 beaker so dissolving the solid in 100 cm^3 (or more) of distilled water would not work.

Once dissolved, many candidates incorrectly transferred to a 250 cm^3 volumetric flask without rinsing the beaker. Others attempted to transfer the solution from the beaker using a burette or volumetric pipette. This mode of transfer would result in some $AgNO_3$ being left in the volumetric apparatus and thus the concentration would be below that intended.

(c) Most candidates realised that brown glass was used to prevent decomposition/reaction of the silver nitrate caused by light.

© 2024

(d) Nearly all candidates knew that filtration was used to remove solid material.

(e) (i)(ii) When choosing appropriate apparatus to measure volumes, candidates need to be aware of the precision of the reading. Step 5 required a transfer of 10.00 cm^3 of a solution. Step 6 required addition of 1 cm^3 of a solution.

In **(i)**, step 5 required volumetric standard apparatus capable of transferring a solution, thus a volumetric pipette of was needed.

In **(ii)**, the precision in step 6 was not so high, so a dropping pipette (or teat pipette) was the most appropriate apparatus.

(f) The use of chemically resistant gloves was well known, although weaker responses did not gain credit for just stating 'gloves'.

(g) The need to rinse a burette with the solution to be used in it, in this case solution **X**, was well known.

(h) (i)(ii) Candidates are getting better at writing titres to a second decimal place, although a few wrote 22.6 for titre 2. Determining the suitable titre to be used in subsequent calculations proved more difficult as many averaged either all four titres or the three accurate titres, instead of two titres within 0.10 cm^3 of each other. Of those who averaged titres 1 and 3, many omitted the second decimal place and 22.4 cm^3 rather than 22.40 cm^3 was often seen.

(iii) Most candidates could start this calculation by correctly calculating the number of moles of $AgNO_3$ in the 250.00 cm^3 standard solution by dividing 10.62 by the M_r of $AgNO_3$ (169.9).

Candidates needed to calculate the number of moles of $AgNO_3$ in the average titre of 22.40 cm^3 standard. This was obtained by multiplying their number of moles of $AgNO_3$ by 22.40 ÷ 250. A common error was to multiply by 22.40 ÷ 1000.

Candidates then needed to realise that because of the stoichiometry of $Ag^+(aq)$ to $Cl^-(aq)$, the number of moles of $Cl^-(aq)$ in 10.00 cm^3 of sea water was the same as the number of moles of $Ag^+(aq)$ in the average titre. To get the concentration of $Cl^-(aq)$ in 1 dm^3, a scaling up of 1000 ÷ 10 was needed.

A very common error in this multi-step calculation was to round earlier answers and 10.62 ÷ 169.9 was given a value of 0.063.

(iv) Although this percentage error calculation was better answered than previous series, many candidates did not perform well.

Half a burette graduation is 0.05 cm^3 and two burette readings had to be made to produce a titre value of 22.60 cm^3. The expected working was:

$$\frac{(0.05 \times 2)}{22.60} \times 100$$

$\frac{0.1}{22.60} \times 100$ was not accepted.

A common error was to make half a graduation equal to 0.005 cm^3.

(i) This was possibly the most challenging question on the paper, with few candidates realising that there must be other ions in the sea water capable of reacting with $Ag^+(aq)$ ions.

© 2024

Question 2

(a) Most candidates correctly identified step 3 as the step used to determine the concentration of $H^+(aq)$ ions from the catalyst

(b) Candidates need to read the question carefully. Two reasons for a reduction in the rate of reaction were asked for. Most realised that the addition of 2.00 cm^3 of the reaction mixture into 150 cm^3 of iced water would lower the temperature of the reaction mixture (and therefore reduce the rate of reaction). Less well appreciated was that addition of 2.00 cm^3 of the reaction mixture into 150 cm^3 of water would drastically reduce the concentration of reactants (and therefore reduce the rate of reaction).

A common error was to firstly give reason 1 as lowering of temperature followed by a description of the kinetic behaviour of particles (e.g., lowering of kinetic energy/less particles that have the activation energy) as reason 2.

(c) (i) The key information to help candidates was given above Table 2.1.

11.40 cm^3 of NaOH(aq) neutralised the $H^+(aq)$ ions from the catalyst. To determine V_t values, 11.40 cm^3 had to be subtracted from each volume of NaOH(aq) given.

V_∞ was the volume of NaOH(aq) used at 60 minutes i.e.V_t at 60 minutes which was 25.90 cm^3 – 11.40 cm^3 = 14.50 cm^3. Thus $V_\infty - V_t$ was equivalent to 14.50 cm^3 – each V_t value.

It was expected that all values in columns 4 and 5 would be given to 2 decimal places.

(ii)(iii) Most candidates recognised time as the independent variable in **(ii)** and that temperature was the variable that needed to be controlled in **(iii)**.

(iv) This question was not well answered. The idea that it did not matter at what time a sample of the reaction mixture had been removed as long as it was correctly titrated against NaOH(aq), then $V_\infty - V_t$ at any time could be determined was not well understood. Many candidates also found it difficult to express their ideas.

Weaker responses stated the time interval must be regular or suggested that 13 minutes was close enough to 10 minutes so that it could be used.

(v) The data was usually correctly plotted, but a large proportion of the candidates assumed a straight line of best fit should be used instead of a curve.

(vi) Nearly all candidates correctly read the missing $V_\infty - V_t$ value at 40 minutes from their graph, but a large number of candidates did not process this $V_\infty - V_t$ value to determine the total volume of NaOH(aq) required to neutralise the total amount of $H^+(aq)$ ions.

(vii) If candidates drew the correct curved line of best fit then the required answer was that the experiment was reliable because there were no anomalous points. If candidates drew a straight line of best fit, this produced anomalous points so the experiment should be deemed unreliable.

Some candidates misinterpreted the requirement of the question and stated the contents of the question and inferred, as the experiment was not repeated, it was not reliable.

© 2024