CHEMISTRY

Paper 0971/12
Multiple Choice (Core)

There were too few candidates for a meaningful report to be produced.

CHEMISTRY

Paper 0971/22
Multiple Choice (Extended)

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

General comments

Candidates found this to be an accessible paper, and a broad spread of marks were obtained. A small number of candidates achieved full marks. Nearly all questions showed good discrimination between candidates, although some candidates found the extended paper challenging.

Candidates found **Questions 5**, **9**, **22**, **23** and **27** to have the least challenge.

Questions 7, **10** and **25** were most demanding.

The link between forces between particles, bonding and physical properties was not well known.

Comments on specific questions

Question 2

Most candidates correctly identified that the collisions between particles would occur less often at decreased pressure, but many confused the effect of pressure on the particle speed and chose option **A**.

Question 7

The properties of ionic and simple covalent compounds were not well recalled. Many candidates confused the forces which are overcome during boiling and chose option **B** or they confused the meaning of the term molecule and chose option **C**. Candidates should be reminded that the word ‘molecule’ is used to describe simple covalent substances and not ionic compounds.

Question 10

This was a particularly demanding question. The most common error was to assume that the ratio of gaseous product to solid ammonium carbonate was 1 : 1 rather than 1 : 3, as shown by the equation. As a result, option **D** was the most commonly chosen option.

Question 15

Most candidates correctly recognised that a lower temperature would not cause particles to collide more frequently. They also recognised that lower pressures do not increase the reaction rate, so option **C** and option **D** were not chosen by many candidates. There was strong discrimination between candidates for the remaining options, with candidates who performed less well overall much more likely to choose option **B**.

Question 16

This question showed strong discrimination between the candidates. Most of the candidates who performed less well overall thought that the addition of a catalyst would increase the equilibrium yield and chose options **A** or **B**.

Question 17

Candidates who performed less well overall were more likely to confuse oxidation and reduction and choose option **C**. Candidates should be reminded that reduction will cause a decrease (i.e. a reduction) in the oxidation number. This would help eliminate two of the options in this question.

Question 19

Most candidates correctly recognised that weak acids are not fully dissociated. Candidates who performed less well overall were more likely to link the strength of the acid to the concentration and choose option **C**.

Question 24

This question discriminated well between candidates. The apparent unreactivity of aluminium and the reactivity series was not well known by candidates who performed less well overall; these candidates tended to choose option **C**.

Question 25

Confusion between reduction, oxidation and the movement of electrons was commonly seen in the responses of candidates how performed less well overall. Option **A** was the most common incorrect answer.

Question 26

The role of cryolite in the extraction of aluminium from its ore was not well recalled. The most common incorrect answers were options **B** and **D**.

Question 29

Most candidates correctly recognised that the product of the addition of bromine to but-2-ene could not be option **B** or option **D**. Candidates who performed less well overall were more likely to choose option **A** than the correct answer.

Question 31

The meaning of the term ‘saturated’ was not well recalled by candidates who performed less well overall. These candidates appeared to be guessing with all the options chosen equally.

Question 32

Many candidates assumed that members of the same homologous series have the same number of carbon atoms and chose option **A**.

Question 33

Most candidates knew that methane was either a gas at room temperature or insoluble in water. A third of candidates confused the test for unsaturation or thought that methane was unsaturated and chose option **B**.

CHEMISTRY

Paper 0971/32
Theory (Core)

There were too few candidates for a meaningful report to be produced.

CHEMISTRY

Paper 0971/42
Theory (Extended)

Key messages

- In questions, such as **Question 1**, where the answer is one of a set of given letters, candidates should be encouraged to make a best attempt guess if they are unsure of the answer as there is no penalty for incorrect answers.
- There is no need for candidates to be taught beyond the requirements of the syllabus. This was apparent in **Question 6(b)(ii)** where many candidates attempted to give the full formula of PET rather than the simplified box notation shown in the syllabus. Similarly, the exact nature of intermolecular forces such as Van der Waals forces, induced dipoles or London dispersion forces are not required.
- Calculations were done well generally, but candidates who performed less well tended to omit their working. If an M_r needs to be determined as part of a solution, the M_r needs to be given as a stated value and not left as an incomplete sum of A_r values.

General comments

There appeared to be sufficient time for all questions to be answered.

Some candidates were still not familiar with some of the newer content of the new syllabus.

If a single answer is asked for, two or three responses should not be given as incorrect statements may contradict correct answers. There were many incidences of candidates giving more than one answer where only one was required and thus not gaining credit.

Candidates should write clearly and legibly enough so their answers are unambiguous. If a mistake is made, candidates should strike through their unwanted response and rewrite a new response.

Comments on specific questions

Question 1

The answers for **(a)** to **(i)** were selected from the list in Table 1.1.

The best answered questions were **(b)** and **(h)**. The hardest were **(c)** and **(f)**.

Many candidates omitted sub-questions. Candidates should be encouraged to make a best attempt guess if they are unsure of the answer as there is no penalty for incorrect answers.

Question 2

(a)(b) Most candidates knew bauxite was the name of the main ore of aluminium in **(a)** and cryolite was added to reduce the operating temperature in **(b)**. Phonetically correct misspellings were allowed but answers such as baux**ide**, cryol**ate** and cryol**ide** were not.

(c) Candidates continue to show a misunderstanding about conductivity as the majority of candidates referred to electrons. Of those who knew that ions were responsible for conductivity of molten compounds, many candidates omitted the key fact that ions must be mobile for conductivity to occur. Vague phrases such as 'free ions' or 'delocalised ions' received no credit.

(d)(i) The main error for was to balance the ionic half-equation with $2e^-$.

Nearly all candidates knew the ionic half-equation for the reaction at the cathode involved Al^{3+} ions, but many were unable to give the complete ionic half-equation. Frequently seen errors included: $Al^{3+} + 3e^- \rightarrow 3Al$; $Al \rightarrow Al^{3+} - 3e^-$ or half-equations showing aluminium ions with incorrect charges.

(ii) Only a few candidates stated the oxidation occurring was due to oxide ions losing electrons.

(iii) Most candidates knew that oxygen reacted with the electrode/anode but many neglected to also specify that the anode was made of carbon/graphite. Candidates who performed less well assumed incorrectly that the reason was due to relative reactivities of oxygen versus carbon dioxide.

(e) Section 9.2.1(c) of the syllabus states that 'aluminium is used in food containers because of its resistance to corrosion'. Very few candidates were able to recall this. Suitable alternatives such as 'aluminium has a protective oxide layer' were allowed. Common errors included 'good conductor of heat' or other properties applicable to all metals rather than specific to aluminium such as 'malleable'.

(f) Many candidates were able to draw correct a dot-and-cross diagram of ions in an ionic bond. Even candidates who performed less well overall were able to insert the charges on the ions.

The most commonly seen error was to show both sets of ions as atoms i.e. A*l* with the configuration of 2,8,3 and F with the configuration of 2,7.

Question 3

(a) Nearly all candidates appreciated that the attraction between the particles must be weak; many candidates omitted to state that the particles involved were molecules.

The common phrase 'weak intermolecular forces' gained full credit, but incorrect statements such as 'weak covalent bonds' did not gain the credit available for the particles involved as covalent bonds are formed between atoms.

(b) The equation was poorly done. Many candidates assumed S was diatomic or C*l* was monatomic, and two very common incorrect responses were $S_2 + Cl_2 \rightarrow S_2Cl_2$ or $2S + 2Cl \rightarrow S_2Cl_2$.

(c) The dot-and-cross diagram of SCl_2 was done very well, and the majority of candidates answered this correctly. Occasionally, diagrams showing all dots or all crosses were seen and some diagrams omitted non-bonding electrons, particularly from the chlorine atoms.

(d) This question tested the ability of a candidate to realise lowering the concentration of the product could be achieved by shifting the equilibrium to the left. Candidates who performed less well struggled with this concept. Other candidates were able to state reducing the concentration of either reactant, or both, would bring about this change. The key piece of information that the (forward) reaction was exothermic was not acted upon that well, and relatively few candidates suggested increasing the temperature.

Weaker responses of 'decrease the pressure' did not realise that the number of moles of reactants equalled that of products.

(e) (i) Section 5.1.5 of the syllabus defines activation energy as 'the minimum energy that colliding particles must have to react'. Very few candidates gave this exact definition. Most candidates opted for simplified or incomplete definitions such as 'the minimum energy for a reaction to take place'.

(ii) The symbol for activation energy, E_a, was well known.

(iii) Most candidates coped well with and knew the effect of changing the conditions stated, but the fact that the most common errors related to knowledge of how the proportion of collisions changed upon increasing temperature and addition of a catalyst suggests that many candidates are still uncertain about particle behaviour during reactions.

(f) Many candidates found this question challenging. Many responses gained no credit, often as a result of describing the oxidations only in terms of electron transfer with no attempt to consider oxidation numbers, despite the question asking for this. The other common error was to confuse oxidation number with ionic charges.

Candidates should be taught that oxidation numbers are whole numbers with a plus or minus sign in front, with the exception of 0. Stating Roman numerals in names such as iron(II) chloride is not sufficient as the oxidation number of the element.

Question 4

(a) The state symbols for this precipitation reaction were generally well known although incorrect use of capital letters as in ‘Aq’ was not uncommon.

(b) Silver nitrate as an alternative aqueous silver salt was frequently seen and was expected as this is what section 7.3.2(b) of the syllabus leads to. However, many candidates thought that if silver ethanoate was soluble then so should silver methanoate, propanoate and butanoate.

(c) A high proportion of candidates answered this question correctly.

(d) Only the better performing candidates were able to recall the colour of silver bromide. Candidates should avoid giving two colours such as white/cream or yellow/cream as this involves the colours of silver chloride and silver iodide.

(e) Many candidates gained full credit for this question. The number of moles of AgBr was most frequently incorrect, as some candidates assumed incorrectly that 0.0100 moles of CH_3COOAg added to 0.0100 moles of NaBr would give 0.0200 moles of AgBr.

Candidates should be reminded that it is good practice to fully evaluate their calculations of M_r and also to state that this number is the M_r. Without showing full working out, it is often not possible to award credit for an error carried forward.

(f) The name of the salt dissolved in the filtrate, sodium ethanoate, was frequently known although insoluble silver bromide was often seen, suggesting these candidates could not distinguish between ‘filtrate’ and ‘residue’.

(g) (i) Most candidates knew the missing step was lack of rinsing, although many candidates opted to state that the precipitate should be heated to constant mass.

(ii) Only the better performing candidates knew that it was the presence of sodium ethanoate which caused the greater mass of residue.

(h) (i) Most candidates were able to gain full credit. Barium oxide was a common incorrect answer as was barium sulfate.

(ii) Some candidates gave incorrect formulae including many who used the wrong symbol for barium, often B or Br.

Question 5

(a) This was well answered with most candidates identifying petroleum (or crude oil) as the source of alkanes used for cracking.

(b) According to section 11.5.2 of the syllabus, the conditions used for cracking are a high temperature and a catalyst. No specific temperature or catalyst is given. Many candidates opted to give specific temperatures and attempted to name the catalyst.

(c) (i) Better performing candidates gained full credit, but many candidates who knew the correct molecular formula of but-1-ene did not form three molecules of it. Thus, the most common incorrect product combination was $C_4H_8 + C_8H_{18}$. If these candidates had referred to the information given in the question carefully, they may have amended their answer to form a total of four product molecules.

(ii) Although ‘thermal decomposition’ was the expected answer many candidates simply gave ‘decomposition’.

(d) (i) Most candidates knew poly(propene) – brackets were not required – was the polymer formed from propene. Candidates should be reminded that handwriting needs to be unambiguous because in many cases ‘polypropane’ and ‘polypropene’ were indistinguishable.

(ii) Many candidates assumed that three units of polymer formed from propene would have three lots of three carbon atoms, (i.e. 9 carbon atoms) in the carbon chain. Of those candidates who realised that three units of polymer would be formed by breaking three C=C bonds to give a carbon chain of six carbon atoms, most went on to insert three methyl side groups in the correct positions.

(iii) Most candidates knew alkenes such as propene underwent addition polymerisation.

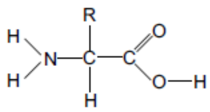
Question 6

(a) (i) This was generally well answered. The most common error was exclusion of the H atom from the N–H bond. Some careless circling overlapped the boxes, thus nullifying the mark.

(ii) Most candidates knew that a dicarboxylic acid and a diamine should be drawn, but many candidates did not follow the instructions to show all of the atoms and all of the bonds in the functional groups. Weaker performing candidates found this very challenging and often merely redrew sections of the molecule shown in Fig. 6.1, complete with amide linkages.

(iii)(iv)(v)
Better performing candidates recalled these three answers with little difficulty.

(vi) Candidates were not familiar with section 11.8.12 of the syllabus, which gives the general structure of amino acids as:

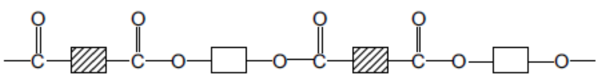


Thus, an amino acid with three carbon atoms would need R to be a CH_3 group.

Nearly all candidates did not place the NH_2 group and COOH group on the **same** carbon atom.

(b) (i) Most candidates opted to give ‘carboxylic acid’ and ‘alcohol’ for their answers as these would make a single ester. Better performing candidates realised that a polyester needs monomers with two functional groups and were able to give the correct answers of ‘dicarboxylic acid’ and ‘diol’ as stated in section 11.8.8(b) of the syllabus.

(ii) The structure of part of PET is shown in section 11.8.10(b) of the syllabus.



Candidates are not required to know the formulae of what the boxes represent. Despite this, it was clear that many candidates had been taught these formulae, but most were unable to write the correct formulae instead of drawing simple boxes.

CHEMISTRY

Paper 0971/52
Practical

There were too few candidates for a meaningful report to be produced.

CHEMISTRY

Paper 0971/62
Alternative to Practical

Key messages

- When plotting graphs, points should be plotted as a cross (x) or an encircled dot (⦿) and not obscured by the graph line, which should be drawn using a sharp pencil. A line of best fit can be curved or straight, whichever is the best fit for the data points. Straight lines should be drawn with the aid of a ruler and not drawn freehand, curves should be smooth and not just a line which moves from point to point. Graph scales should be chosen such that the plotted data takes up over half of the available space and it is recommended that each major grid line should be equivalent to 1, 2, or 5 (or those numbers multiplied by 10^n) – this is indicated in the Presentation of Data section of the syllabus in the section entitled 'Graphs' (and also recommended by the Association for Science Education (A.S.E.)).

- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).

- In the qualitative analysis question (**Question 3**) where a question states 'any gas produced is tested' then candidates are expected to record the details for the gas test that gives a positive result. Candidates are expected to use the term 'precipitate' when describing the formation of a solid from the reaction between two solutions. If, when two solutions are mixed the product becomes cloudy and opaque, then a precipitate has been formed. To state that a gas is given off is not an observation. The relevant observation would be effervescence or fizzing or bubbles (of a gas).

- When a question asks for the name of a chemical, a correct formula is normally acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded. When a question asks candidates to identify ions or a substance then candidates may answer using names of formulae.

- In qualitative analysis, not all of the tests described will necessarily give a positive result; a negative test result is useful since it tells us that a certain ion is not in the compound being tested.

General comments

The vast majority of candidates successfully attempted all of the questions, and the full range of marks was seen. The vast majority of candidates were able to complete all questions in the time available. The question paper discriminated successfully between candidates of different abilities but was accessible to all. The questions were generally well-answered, with very few blank spaces.

Some candidates omitted questions when the answer needs to be written on a diagram and there is no dotted answer line. These errors of omission would not occur if candidates read the whole of the questions on the examination paper rather than just looking for dotted lines on which answers should be written.

In answering the planning question (**Question 4**), there is no need for candidates to write a list of apparatus at the start, nor the aims of the experiment, nor a list of safety precautions or a list of dependent and independent variables. Where there is credit available for the use of suitable apparatus, then this will only be awarded if it is stated what the apparatus is used for. Credit will not be awarded just for a name in a list of other apparatus.

Comments on specific questions

Question 1

(a) The majority of the candidates realised that the mercury(II) bromide in the left hand boiling tube should be heated. A small minority of candidates drew an arrow to show the ice in the beaker being heated. It was not uncommon for candidates to not attempt this question part, presumably because they had not seen it, as it required something to be added to the diagram rather than on a dotted answer line.

(b) The vast majority of candidates identified the apparatus as a boiling tube or test-tube. Vague answers, such as 'tube' alone did not gain credit.

(c) The majority of candidates were able to identify the process as electrolysis.

(d) There were three acceptable reasons why platinum is a suitable material for the electrodes:

- It is a good conductor of electricity. 'Good conductor' alone was insufficient as platinum, in common with all metals, is also a good conductor of heat.
- It melts above the boiling point of the electrolyte. A statement of it having a high melting point was also sufficient.
- It is inert or unreactive. Statements that platinum did not react with a substance in the boiling tubes, such as mercury(II) bromide or bromine, were sufficient. Statements saying platinum did not react with water or did not rust did not gain credit as there was no water in the boiling tube and so that property is irrelevant.

A significant number of candidates gave the same reason twice, normally by stating that the platinum will not react as one reason and then stating it is inert as the other reason. These are two equivalent statements and so can only be credited once.

(e) Candidates who used the data in Table 1.1 or who were aware that mercury had a high density correctly showed that the mercury would collect at the bottom of the left-hand boiling tube. A common error was to show the mercury in the test-tube in the ice-bath, presumably because they thought the mercury would have boiled off.

(f) This question asked for an explanation. Simple statements saying that the ice cooled something were insufficient as it did not say why it needed to be cooled. The idea of the condensation of a gaseous product to a liquid product was required. Answers in terms of the condensation of steam to form water were rejected as there is no water anywhere in this reaction. Many candidates gave full answers, stating that the ice cooled the bromine gas so that it formed liquid bromine.

Question 2

(a) The majority of candidates performed well. The most common errors were either not recording the volumes of sodium thiosulfate to the same resolution (number of decimal places) or recording the time to one decimal place. The practical instructions stated 'record the time in seconds to the nearest whole number'. A small minority of candidates left the times in minutes and seconds or completely ignored the minute hand and so gave answer showing just the seconds and ignoring the minutes.

(b) The ideal scale to use was one where each big grid square was equivalent to 20 seconds. Candidates who used this scale were normally able to plot all five points correctly. A significant number of candidates opted for more awkward scales, such as each big grid square being equivalent to 30 seconds. While this scale was acceptable, it often resulted in errors in plotting the data from Table 2.1. A best-fit curve was asked for; better performing candidates treated the point at (7, 63) as an anomaly and drew excellent smooth curves which ignored this point. It was very common for candidates to not treat any of the points as anomalous and draw a curve which meandered over the grid, taking in all five points; these candidates did not receive credit for drawing the best-fit line.

(c) The best answers correctly stated that the contents of the beaker were stirred to evenly distribute the solutions. It was sufficient to just state that the contents were stirred to mix them. Most answers that did not gain credit stated that the contents were stirred to make the reaction faster or to dissolve the substances.

(d) Almost all candidates were able to identify Experiment 1 as having the highest rate of reaction. A small minority of candidates opted for Experiment 5, which had the longest time.

(e) Many candidates gained full credit. Marks were awarded for:

- Working shown on the graph at $12.5\,cm^3$. Ideally, this should be a line up from $12.5\,cm^3$ on the *x*-axis to the line and across to the *y*-axis. It was not uncommon for candidates to use 12, 12.05 or 13 rather than 12.5.
- A correct reading from the *y*-axis. Candidates who had chosen a more difficult scale were more likely to make an error on the reading compared to those who had each big grid square as 20 seconds.
- Giving correct units for their value. This should have been ‘s’ but ‘seconds’, ‘sec’ or ‘secs’ were accepted.

(f) (i) The fact that a burette is more accurate than a measuring cylinder was well known.

(ii) It is evident that some candidates were not aware of the difference between a dropping (Pasteur) pipette and a volumetric pipette. A very common incorrect answer was to say that pipettes only add small volumes or drops. The required answer was that volumetric pipettes only measure a fixed volume, and the volumes of aqueous sodium thiosulfate were not fixed or did not match the sizes of volumetric pipettes available. A few candidates also correctly stated that addition from a volumetric pipette is slow and so the reaction would have started before all of the aqueous sodium thiosulfate was added.

(iii) If an investigation is giving reliable results, then each time the experiment is done the results obtained will be the same or similar. To check the results are reliable, the experiment needs to be repeated, and the results compared to see if they are similar. Repeating and finding the mean improves accuracy (as random errors are removed) but does not check reliability. Many candidates did not gain credit because they ‘repeated and found the mean’ but did not compare.

(g) This was a demanding question. The best answers explained that as a greater depth of liquid would be looked through, it would make it harder to see the text and so the times for the text to become visible would increase. A very common error was to say that the ‘rate of reaction would not change, as the solutions had the same volume, concentration or temperature’.

(h) Most candidates realised that the key to this question was the temperature. To determine whether the reaction is exothermic or endothermic, the change in temperature from the start to the end needs to be found. Candidates who just stated ‘measure the temperature’ did not gain credit as just measuring the temperature once will not tell you if it has increased or decreased. A common error was to name the apparatus required rather than state the measurements.

Question 3

(a) Many candidates were able to state that a yellow flame is not hot enough or that the yellow colour will mask or prevent them seeing the flame test colour and so gained credit. Candidates who just stated ‘a roaring flame should be used’ did not gain credit as they had not said why the yellow (safety) flame is not suitable.

(b) Many fully correct answers were seen. The two most common errors were:

- to give chromium(III) as one of the ions. While chromium(III) ions do give a green precipitate when reacted with aqueous sodium hydroxide, the precipitate will dissolve in excess sodium hydroxide. In **test 3** in Table 3.1, the precipitate did not dissolve in excess.
- to give nitrate as one of the ions. While **test 4** in Table 3.1 is the test for nitrate ions, the result was negative and so shows there are no nitrate ions in solid **M**.

(c) The mark allocation of two indicates to candidates that two observations were required. The question states 'any gas produced is tested', so answers should have recorded the details for the gas test that gives a positive result. Many candidates correctly stated that there would be effervescence and that the gas would turn limewater milky.

(d) The test described is the test for ammonium ions and so ammonia gas should have been produced. As the question states 'any gas produced is tested' answers should have recorded the details for the gas test that gives a positive result, which in this case is that damp red litmus turns blue.

(e) The addition of aqueous ammonia is used to identify the presence of some metal ions, as the cation in **N** is ammonium, there should have been no observed change on adding aqueous ammonia.

Question 4

Candidates who realised that the best way to determine which of two solutions contains the greater concentration of acid is to carry out a titration, often performed well on this planning task. Some excellent and succinct descriptions were seen. As this was a quantitative task, there was a requirement to control volumes of reagents.

The expected steps in the titration were:

- add a specified volume of one reagent to a suitable reaction vessel, such as a conical flask
- add a named acid-alkali indicator, such as methyl orange, to the conical flask
- add the other reagent gradually to the contents of the conical flask using a burette
- swirl the flask while adding the reagent from the burette
- stop adding the reagent from the burette when the colour changes
- describe how the results will show which juice contains the more concentrated citric acid.

The more common errors were to not specify a volume of the reagent in the flask, not to name an appropriate indicator and not to mix the contents of the flask during the titration. It should be noted that universal indicator is not appropriate to use in a titration. A common error was to use DCPIP as the indicator. DCPIP is not used as an acid-base indicator; it is a redox dye and can be used to assess the amount of vitamin C (ascorbic acid, not citric acid) in a sample – the vitamin C reduces blue DCPIP to a colourless compound.

The most common alternative method seen to a titration was to base the investigation on rate of reaction. In these cases, candidates added a known volume of aqueous sodium hydroxide to a known volume of juice and timed something. The problem with this method is that there is no visible change in the reaction, no gas is made and so no gas can be collected nor fizzing observed. Adding an acid-alkali indicator and timing a colour change will not work as the reaction when an acid reacts with an alkali is oppositely charged ions combining ($H^+ + OH^- \rightarrow H_2O$) – this reaction is almost instantaneous.