CHEMISTRY

Paper 0971/12
Multiple Choice (Core)

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

General comments

Questions 3, **7**, **10**, **15**, **17**, **19** and **32** had the lowest demand.

Questions 8, **20**, **29**, **36**, **38** and **40** were found to be more challenging. Overall the questions on organic chemistry were least well answered.

Comments on specific questions

Question 2

Most candidates were able to correctly reject option **D**, but all other options were popular responses. Candidates should recall that a substance will be a liquid at a temperature between the melting and boiling points.

Question 4

All the options were chosen in a ratio that suggests many were guessing the position of the solvent front.

Question 8

Options **A** and **B** were the most common incorrect answers selected. In option **A**, candidates assumed that the number of hydrogen atoms was equal to the number of bonding electrons and for option **B**, candidates counted the correct number of bonds but did not recall that each bond would contain two electrons.

Question 12

Although most candidates gave the correct option, **C**, option **B** was also chosen frequently suggesting that many candidates were unclear which particle was chosen as the comparison for relative masses.

Question 13

The majority of candidates incorrectly chose option **A** or option **B**. The question tells candidates that the initial solution was neutral so the initial colour should be green not blue.

Question 20

Most candidates identified the correct colour change but thought that the addition of water would cause the temperature to fall.

Question 21

Properties of acids and bases were not commonly known. Although option **A**, the correct answer, was the most common option chosen, the distribution of options chosen suggested many candidates were guessing.

Question 29

Option **C** was a popular incorrect choice. The majority of candidates incorrectly chose a solid ionic substance as an electrical conductor, not recognising that the alloy would be a solid conductor.

Question 36

Option **C**, the key, was the least popular answer. Candidates did not recognise that three fractions had been chosen and the boiling point was not listed in descending order.

Question 38

Most candidates thought that yeast is fermented rather than glucose. Only a minority were able to identify water as steam as a product of combustion of ethanol.

Question 40

Most candidates were able to recall the reaction of acids with $CaCO_3$ and their effect on methyl red but did not recognise CuO as a basic oxide, which would also react. The incorrect option **D** was the most popular answer.

CHEMISTRY

Paper 0971/22
Multiple Choice (Extended)

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

General comments

Questions 2, **10**, **17**, **19**, **27** and **35** had the lowest demand. **Questions 15**, **29**, **36**, **37** and **39** were found to be more challenging. Questions on organic chemistry were least well answered.

Comments on specific questions

Question 1

This question was well answered by many candidates. Some candidates showed little understanding and responses suggested a high degree of guessing.

Question 5

Although most candidates correctly chose option **A**, some candidates gave option **D**, thinking distillation relies on a difference in solubility**.**

Question 7

Some candidates were more likely to choose option **D** than any other response, suggesting a poor recall of bonding in molecules listed in the syllabus.

Question 13

Most candidates made an attempt at this calculation. Some candidates tended to choose option **B** more frequently than the key, option **C**.

Question 14

Most candidates correctly identified the energy released being greater than the energy needed for the exothermic reaction. Some candidates gave option **C** thinking that bond breaking released energy.

Question 15

Candidates tended to complete the calculations well but did not pay enough attention to the units. Information on energy was given in both J and kJ and volume in both cm^3 and dm^3. As a result, many candidates were confused and gave option **C**.

Question 18

Few candidates gave option **C**, suggesting a good understanding of the effect of adding more reactants on the yield of ammonia. The effect of temperature on yield was less well understood BY some candidates who selected option **D**.

Question 21

Only a small majority of candidates identified the correct proton transfer in this reaction. Some candidates incorrectly thought this was a redox reaction and gave option **B**.

Question 22

Some candidates performed well on this question. However, there was evidence to suggest guessing by other candidates, as each option was chosen with equal popularity.

Question 26

Many candidates incorrectly gave option **C**, although a few gave option **A**. Only a minority were able to use typical properties of syllabus elements to identify this ‘new element’.

Question 29

Option **C** was a popular incorrect choice. The majority of candidates incorrectly chose a solid ionic substance as an electrical conductor, not recognising that the alloy would be a solid conductor.

Question 32

Most candidates correctly identified a test for zinc ions. Only a minority of candidates recognised the decomposition of a nitrate presented as a chemical test. Option **C** was a popular incorrect answer.

Question 36

Structural isomerism was not well known. The majority of candidates thought that all the structures were different isomers and chose option **A**.

Question 37

The addition reactions of alkenes were not well known. All possible responses were popular suggesting a significant degree of guessing.

Question 38

Some candidates thought that it was the yeast that was converted to ethanol rather than the glucose or confused oxygen as a product rather than a reactant in combustion.

Question 39

The properties of nylon and *Terylene* were not well known. All responses were almost equally popular suggesting a significant degree of guessing.

CHEMISTRY

Paper 0971/32
Theory (Core)

Key messages

- It is important that candidates read the stem of the question carefully in order to understand what is exactly being asked.
- Some candidates needed more practice in answering questions involving standard chemical reactions including organic chemistry.
- Many candidates needed further practice in writing definitions and answers with precision.
- Interpretation of data from tables and graphs was generally well done, as were simple calculations.

General comments

Many candidates tackled this paper well, showing a good knowledge of core chemistry. Many candidates answered every part of each question, although others did not respond to one or more questions. The standard of English was generally good; some candidates needed more practice in writing with precision.

Some candidates needed more practice in reading and interpreting questions. In some questions, the rubric was misinterpreted or ignored by a significant number of candidates. For example, in **Question 1(a)(iv)** many selected carbon despite the question asking for the name of a metal and in **Question 1(a)(v)** many candidates ignored the word ion and suggested chlorine. In **Question 2(c)(iii)**, many candidates did not refer to the diagram. In **Question 6(a)**, most candidates gave specific names of the products of electrolysis rather than observations. Candidates should be encouraged to revise the meaning of specific command words. In **Question 6(c)**, many candidates wrote about chemical changes rather than physical changes. In **Question 7(b)(iv)**, most candidates referred to time rather than rate. In **Question 8(b)**, many candidates did not follow the instruction to tick two boxes.

Many candidates needed practice in revising standard chemical reactions such as the reaction of acids with bases (**Question 4(b)**) and metals with acids (**Question 8(a)(i)**). Others needed more practice in selecting relevant chemical tests, e.g. for unsaturation (**Question 5(e)**) and for water (**Question 8(e)(ii)**). Many candidates needed further revision of organic structures and reactions (**Questions 5(a), 5(e) and 5(f)**).

Some candidates had learnt chemical definitions well; others needed more practice in memorising these. For example, in **Question 1(b)** (definition of the term *element*) many omitted essential details or wrote about molecules. In **Question 5(d)** (definition of the term *hydrocarbon*), many omitted essential words such as 'only' or 'compounds'. Many candidates needed further practice in writing specific answers rather than providing vague or unqualified statements. For example, in **Questions 3(a)** and **3(b)** (relating properties to uses), many candidates did not discriminate sufficiently between the various possibilities given in the table. In **Question 8(d)**, many omitted essential details and wrote their answers down in a disordered fashion.

Many candidates were able to extract information from graphs as well as from tables. Many candidates were able to undertake simple calculations involving relative formula mass and calculations involving simple proportion; others needed to revise these areas.

Questions involving atomic structure were generally tackled well by many candidates, as was the completion of symbol equations.

Comments on specific questions

Question 1

This was one of the better answered questions on the paper. Most candidates identified at least two of the elements correctly in **(a)**. Many performed well in **(b)(ii)** and **(c)**. Fewer candidates gave a convincing definition of the term *element* in **(b)(i)**.

(a) (i) Many candidates identified argon as the inert gas. The commonest error was to suggest oxygen. The incorrect responses iodine or aluminium were occasionally given.

(ii) A minority of the candidates identified calcium. The commonest incorrect answer was chlorine. The incorrect responses carbon or oxygen were also frequently seen.

(iii) Many candidates realised that potassium forms an ion by loss of an electron. The commonest incorrect answers were the halogens (usually bromine or fluorine), which form ions by gaining an electron.

(iv) Few candidates identified the metal used as an inert electrode. The commonest incorrect answer was iron. Some candidates did not read the question carefully enough and chose potassium (a very reactive metal) or the non-metals iodine or carbon.

(v) A minority of the candidates recognised the test for iron(II) ions. The commonest incorrect answer was chlorine. Candidates chose this because it is green in colour but ignored the fact that chlorine is not ionic. Other common errors were to suggest either zinc or aluminium.

(b) (i) Few candidates gained credit for a suitable definition of an element. Many wrote vague statements such as ‘a group of atoms bonded together’ or ‘a substance having only one atom’. The best answers referred to there being ‘only one kind of atom present in the substance’ or that an element is ‘a substance which cannot be broken down further chemically’. In the latter definition, many candidates omitted ‘broken down chemically’, which was essential. Many candidates referred to molecules rather than atoms, forgetting that molecules can contain different kinds of atoms.

(ii) Many candidates deduced the correct number of protons and neutrons. The commonest incorrect answers for the number of protons were 35 (mass number) or 18 (number of neutrons). The commonest incorrect answers for the number of neutrons were 35 (mass number) or 17 (number of protons).

(c) Most candidates gave the correct electronic structure of chlorine. The commonest errors were eight electrons in the outer shell, two electrons in the outer shell or four electrons in the second shell.

Question 2

Most candidates were able to extract the information from the table in **(a)(i)** and **(a)(ii)**. Fewer were able to calculate the mass of carbon monoxide in **(a)(iii)**. A small minority of the candidates knew the sources, effects and uses of sulfur dioxide in **(b)**. In **(c)(i)** and **(c)(ii)**, many candidates were able to complete the equation and the energy level diagram correctly. Fewer were able to explain why the reaction is exothermic in **(c)(iii)**. Parts **(d)** (catalysis), **(e)** (pH of acid) and **(f)** (Brownian motion) were well answered by a majority of the candidates.

(a) (i) Most candidates were able to extract the information from the table. The commonest incorrect answer was ozone.

(ii) Nearly all the candidates selected the correct answer ‘particulates’ from the table. The commonest incorrect answer was carbon monoxide.

(iii) Some candidates were able to use simple proportion to obtain the correct answer. Others needed more practice at this. The commonest errors were 0.0125 (obtained by dividing 2.5 by 200), 0.2 (obtained by dividing 200 by 1000) or 12.5 ($2.5 \times 1000 \div 200$).

(b) (i) Very few candidates were able to suggest a suitable source of sulfur dioxide. Many just referred to incomplete combustion or car engines. Others wrote vague statements about ‘waste from factories’, ‘from crude oil’ or ‘from distillation’.

(ii) The best answers referred to erosion of limestone or corrosion of metals. Many candidates wrote about ‘discolouring of paintwork’ or extreme suggestions such as ‘making the buildings fall down’ or ‘destroying buildings’.

(iii) This was the least well answered part of **Question 2**. Many candidates suggested ‘making sulfuric acid’, which was not accepted because sulfur dioxide is formed ‘in situ’ in the Contact process. Other incorrect suggestions included ‘cleaning materials’ or ‘chemical tests’. These answers were too vague. A significant number of candidates did not respond to this question.

(c) (i) Most candidates balanced the equation successfully. The commonest errors were $3SO_2$ or $4SO_2$. A few candidates wrote symbols such as C or O on the dotted line instead of numbers.

(ii) Most candidates wrote either the words or the symbols in the correct places on the energy level diagram. Some wrote ‘products’ on the left and ‘reactants’ on the right. Another common error was to write products in the middle of the arrow.

(iii) Some candidates gave a good explanation in terms of the reactants having more energy than the products. Others did not refer to the instruction to use the information from the diagram and just defined an exothermic reaction.

(d) Most candidates gave a good explanation of the term *catalyst*. The commonest error was to write vague statements such as ‘a substance which changes the rate of reaction’. A few candidates suggested that a catalyst ‘neutralises a reaction’.

(e) Many candidates selected the correct pH value. The commonest error was to suggest pH 7. The second commonest error was to suggest pH 9.

(f) Many candidates selected the correct statement. Others chose the first statement (particles move from higher concentration) or the third statement (Brownian motion is example of diffusion) in about equal number.

Question 3

Some candidates performed well in both **(a)** and **(b)** giving answers which highlighted exactly why the substances were chosen for either an electricity cable or cutlery. Others tried to write about all the properties in the table and a considerable number of candidates ended up contradicting themselves. Many candidates did not write with sufficient precision.

(a) Many candidates identified **E** as being the best substance to be used for electricity cables. Some candidates wrote too much and included all the properties in the table. These candidates often wrote contradictory statements. Many candidates did not write with precision and did not make the distinction between the very good electrical conductivity and very good ductility of **H** and the good electrical conductivity and ductility of **E** and **F**.

(b) Few candidates identified **E** as being the best substance to be used for cutlery. Many candidates wrote too much and included all the properties in the table. Many did not make the distinction between the very good resistance to corrosion and the very good strength of **E** and the good resistance to corrosion and strength of **G** and **H**.

Question 4

This was the best answered question on the paper with many candidates performed well in **(a)(ii)** (formula of organic compound), **(a)(iii)** (calculation of relative molecular mass), **(c)(i)** (naming calcium sulfate) and **(c)(ii)** (properties of ammonia). Fewer candidates were able to identify the carboxylic acid functional group in **(a)(i)** or to complete the equation in **(b)**.

(a) (i) Some candidates recognised the carboxylic acid functional group. Others selected the alcohol functional group or the C=O group within the COOH group. A minority of candidates selected the C=C double bond. A significant number of circled extra atoms. For example, many circled the C=C as well as the COOH group.

(ii) Many candidates were able to deduce the correct molecular formula for compound **J**. The commonest error was to miscount the number of carbon atoms, $C_8H_{10}O_3$ or $C_7H_{10}O_3$ being frequently seen. Another common error was to suggest that there are four H atoms rather than three. A minority of the candidates wrote the formula as $C_6 + H_{10} + O_3$, which was not accepted.

(iii) Many candidates were able to deduce the correct relative molecular mass of compound **J**. Credit was given for those candidates who wrote the incorrect molecular formula in **(a)(ii)**, but did the correct calculation using this formula. A considerable number of candidates did not use the correct atomic masses or made multiplication errors. This was usually observed with candidates who made counting errors in **(a)(ii)**. The commonest examples of this were $8 \times 2 = 16$ or $8 \times 16 = 96$. It was not uncommon to see eight oxygen atoms used even when **(a)(ii)** was correct.

(b) Some candidates gave calcium chloride and water as the correct products. Others seemed to guess the products and it was not uncommon to see atoms which were not present in the reactants. The commonest example of this was carbon dioxide. Common errors included the inclusion of chlorine, calcium hydroxide, calcium and hydrogen chloride.

(c) (i) A majority of the candidates named calcium sulfate correctly. A few muddled the sulfate with the sulfide or sulfite but a greater number of candidates did not recognise the group of sulfur and oxygen atoms and wrote answers such as calcium sulfur oxide or calcium sodium hydroxide. The latter was likely to have been through lack of learning of symbols (S = sodium rather than Na).

(ii) The commonest errors were to suggest solid or liquid for the state of ammonia or to suggest that the litmus paper turned pink, despite red being the initial colour stated in the question.

Question 5

The answers to most parts of this question showed that many candidates needed more practice in revising organic chemistry. Part **(b)** (balancing an equation) was generally well answered by a majority of the candidates. Most needed more practice in describing hydrocarbons (**(d)**), in recollecting the bromine water test (**(e)**) and in cracking (**(f)**).

(a) Some candidates drew the correct structure of ethane. Common errors included omission of two hydrogen atoms (usually seen as an ethene structure with the double bond converted to a single bond), ethene rather than ethane, ethanol or pentavalent carbon atoms.

(b) A majority of the candidates balanced the equation correctly. The commonest error was to suggest $2CO_2$. The water was sometimes unbalanced; $3H_2O$ or $6H_2O$ were errors which were frequently seen.

(c) (i) Very few candidates could state a process which puts methane into the atmosphere. The commonest errors were to suggest ‘combustion’, ‘acid rain’ or ‘fossil fuels’. A significant number of candidates misread the question and gave a use rather than a process.

(ii) Few candidates could state a major use of methane. The commonest errors were to suggest ‘greenhouse effect’, ‘petrol for a car’ or ‘fertilisers’.

(d) The commonest error was to omit the important word 'only' (or no other elements). Many candidates did not mention that hydrocarbons are compounds. This is an important word to include since 'it contains hydrogen and carbon' could refer to a mixture of hydrogen and carbon. In fact, many candidates did refer to a hydrocarbon as being a mixture. This is a common error.

(e) Few candidates knew the bromine water test for unsaturation. A wide variety of incorrect test reagents were seen including sulfur dioxide, water and carbon dioxide. A significant number of candidates did not respond to this question.

(f) (i) Some candidates remembered that hydrogen is an element, which is the product of cracking. A majority of the candidates appeared to guess the answer. Many did not heed the term *element* in the question and gave the names of compounds such as propane, carbon dioxide or methane. A significant number of candidates gave 'bromine'. A significant number also did not respond to this question.

(ii) Some candidates recognised that a high temperature is required for cracking. Others just wrote 'temperature', which is too vague. Other errors frequently seen included 'pressure' or 'carbon'. A significant number of candidates did not respond to this question.

Question 6

This was one of the least well answered questions on the paper. In **(a)**, hardly any candidates gave observations. Most gave the names of the elements produced. In **(b)**, many candidates muddled the term *arrangement* with the term *separation*. In **(c)**, many candidates confused the physical properties of sodium and iron. In **(d)**, many candidates did not refer to the carbon monoxide or tried to answer the question in terms of electron transfer.

(a) Nearly all the candidates gained credit for their labelled diagram. In the first section of the question, nearly all gave the names of the elements produced rather than observations. Many candidates did not label their diagrams fully as requested. It is important that a power pack, if drawn as a rectangle, is labelled as it could be another piece of equipment. Some candidates labelled the rectangle with a 'V'. Many candidates did not show the surface of the electrolyte so that the electrodes were in the air. The labelling of the positive and negative electrodes (anode and cathode) was often not accurate enough. Candidates should be advised to draw a clear line linking the word to the body of the electrode. Many candidates positioned the labels next to the connecting wires rather than the electrodes.

(b) Many candidates did not recognise the term *arrangement* in reference to particles. Many muddled *arrangement* with *separation* and so wrote the same answer twice, sometimes in a slightly different way. Others suggested that the particles were 'a little way apart'.

(c) Some candidates selected two of the physical properties which differentiate Group I metals from transition elements. Others either gave chemical properties or chose physical properties, which were not relevant such as a suggested comparison of electrical conductivity or lustre. A considerable number of candidates muddled the properties of sodium and iron. For example, some suggested that sodium had a high melting point and was harder than iron.

(d) Some candidates overcomplicated their answers by writing about electrons. In order to get credit for this route, responses would have to state that the carbon in the carbon monoxide loses electrons. The best answers stated simply that 'carbon monoxide gains oxygen'. Many candidates focused on the iron oxide losing oxygen instead of the carbon monoxide gaining oxygen. Others wrote vague statements about the products such as 'the carbon dioxide has more oxygen than before' or that 'there are two O's in CO_2 and 1 in CO'.

Question 7

Part **(b)** of this question about rates of reaction was generally well answered by candidates, apart from **(b)(i)** where any candidates confused volume of oxygen with rate of reaction. Others drew incorrect diagrams (sometimes unlabelled) for **(a)** or did not respond to this part. In **(c)**, only a minority of the candidates identified the element which was most likely to act as a catalyst. In **(d)**, the test for oxygen was fairly well known.

(a) Some candidates drew clearly labelled diagrams using a ruler. Others labelled parts of their diagram as a syringe even though it bore no resemblance to a gas syringe. Many candidates needed to improve their drawing of pieces of chemical apparatus. Those who drew a presumed measuring cylinder without graduations, or a label did not gain credit because the drawing could be confused with a gas jar. A significant number of candidates drew apparatus which included a measuring cylinder as well as a syringe, with the measuring cylinder often connected to the side or end of the syringe by a tube. A significant number of candidates did not respond to this question.

(b) (i) A minority of the candidates realised that the rate was related to the change in gradient of the graph with time. A majority of the candidates incorrectly equated rate with the increase in volume and therefore suggested that the rate increased until it stopped. A few candidates recognised that the rate decreased but started their answer with 'the rate increases at first' before mentioning that it decreases.

(ii) Most candidates deduced the correct time to collect 60 cm^3 of oxygen. The commonest error was 10.1 seconds due to thinking that each small square on the graph was 0.1 second.

(iii) Many candidates gained credit for drawing the line correctly. Others drew the line so that the final volume of oxygen was greater than 96 cm^3. A minority of candidates started their line at, for example, 5 seconds rather than at (0,0). A significant number did not respond to this question.

(iv) Most candidates realised that the rate increased. The commonest error was to write about the time taken rather than the rate.

(c) A minority of the candidates realised that transition elements such as nickel were good catalysts. The commonest error was to choose magnesium. Other incorrect choices frequently seen were sodium or sulfur.

(d) Many candidates know the correct test and result for oxygen. Others gave the incorrect test and consequently an incorrect result. Common errors included 'lighted splint pops', using sodium hydroxide or barium hydroxide as a test reagent, 'things burn in the presence of oxygen' or 'flame test'.

Question 8

This question was well answered by some candidates. Parts **(c)** and **(e)(i)** were generally well answered by candidates. Others made errors identifying the products of the reaction between iron and hydrochloric acid in **(a)** and in explaining in detail how to prepare crystals of pure, dry cobalt chloride in **(d)**. The colour change in **(b)(i)** was not well known.

(a) Some candidates gave the correct products for the reaction of iron with hydrochloric acid. Others needed more practice in revising basic chemical reactions. Common errors included iron hydroxide or iron oxide instead of iron chloride and water or oxygen instead of hydrogen. Many candidates did not write precisely and wrote iron salt instead of iron chloride.

(b) The commonest error was to tick the fourth box down (iron is oxidised by carbon). Many candidates also suggested that iron ore is bauxite. A significant number of candidates did not respond to the instruction to tick two boxes and only ticked a single box.

(c) A majority of the candidates gave the correct order of reactivity. The commonest error was to reverse iron and chromium.

(d) The best responses mentioned filtering off the excess solid, heating to the point of crystallisation and drying with filter paper. Few candidates gave a fully complete answer and many did not write with sufficient precision. Most candidates wrote vague statements such as ‘heat to form the crystals’ or ‘evaporate the solution to get the crystals’. Others contradicted themselves or wrote their answers in a confusing sequence. Few candidates suggested washing the crystals with cold water or organic solvent. It was common to see references to the initial filtration and drying with filter paper. A significant number of candidates suggested heating in an oven, which would dehydrate the crystals unless a low temperature had been specified. A significant number of candidates did not respond to this question.

(e) (i) Most candidates identified the symbol for a reversible reaction. The commonest errors were to suggest ‘equals’, ‘interchanges’ or ‘equation is balanced’.

(ii) A minority of the candidates gave the correct colour change when water is added to anhydrous cobalt(II) chloride. Many candidates appeared to muddle the colour changes with those of anhydrous copper(II) sulfate. Few candidates gave colours other than blue, pink or white.

CHEMISTRY

Paper 0971/42
Theory (Extended)

Key messages

- Candidates must ensure that they read questions carefully to ensure that the answer they give addresses what has been asked. This was particularly evident in parts of **Question 1** where questions related to ions but were answered in terms of atoms and in **Question 4(b)** where alcohols were drawn rather than the alkenes that formed the alcohols.

- When a chemical equation is asked for, this means a balanced symbol equation using correct symbols / formulae and not a word equation. Word equations were frequently seen in **Question 3(c)(ii)** and **Question 4(c)**.

- If a name is asked for, although a correct symbol / formula would get credit, a wrong or even a 'near-miss' incorrect formula would receive no credit.

- Candidates should be prepared to do calculations using moles and their ratios. If the calculation is unstructured, such as **Question 2(e)**, then candidates need to explain their shown working rather than presenting apparently random sums if partial marks are to be awarded.

- When describing physical properties (e.g. **Question 3(b)**) a substance having a high melting point will naturally have a high boiling point, so candidates need to treat these physical constants as being equivalent and not two different physical properties

General comments

Most candidates appeared to be well prepared for this paper. It was evident that some candidates were unfamiliar with some areas of the syllabus (such as organic chemistry).

Many candidates followed question rubrics and did not give more than one response when one was asked for; very few produced lists.

When drawing organic structures, candidates should be aware that structures will require all bonds to be drawn and thus the valency of the atoms used needs to be correct. Trivalent or even pentavalent carbon atoms were often seen.

Comments on specific questions

Question 1

(a) This was answered well by most candidates. Weaker responses tended to include errors as a result of counting the electrons in the structures and ignoring the fact that some were ions.

(b) Most candidates correctly identified **F** as the incorrect structure. Weaker responses had difficulty expressing the reason sufficiently well enough. The most common incorrect reasons given for choosing **F** were that 'electrons are not paired in the outer shell' or 'the *outer* shell is not complete'.

(c) Candidates had to count the electrons (10) and realise that a 2+ charge meant that the number of protons exceeded the number of electrons by two. Many simply assumed number of electrons were equal to number of protons and gave 10 as their answer, whilst others assumed the number of protons was two less than the number of electrons.

(d) (i) This was found to be the most difficult part in the question. A species with two electrons and a charge of –1 needs to contain 1 proton, thus H^- was the answer. Although ‘H’ was accepted, many incorrectly gave ‘hydrogen’.

(ii) Most candidates realised that aluminium was the element whose ion had a 3+ charge and 10 electrons. Weaker responses opted for nitrogen, incorrectly.

Question 2

(a) Many candidates knew that the correct acid was nitric but wrote the name, which was not credited. ‘H_2NO_3’ was a frequently seen error, as was ‘NO_3^-’. A significant number of candidates opted to make things hard for themselves by writing an equation for the reaction between nitric acid and a carbonate. If ‘HNO_3’ was seen as a reactant, credit was given.

(b) (i) The majority of candidates appreciated the need to react all the acid.

(ii) Candidates need to be aware that observations are based upon what is seen rather than what can be concluded. Thus, ‘no more carbon dioxide given off’ received no credit as what would be seen is ‘no more effervescence’.

Candidates who wrote ‘a precipitate forms’ received no credit for this response. Precipitates form when two solutions (react to) form a solid. Here, it was a solid not dissolving.

Weaker responses described the reaction rather than its cessation, and phrases such as ‘fizzing’ and ‘dissolving’ were seen.

(iii) Only the strongest of responses appreciated that (thoroughly) rinsing the residue would achieve a maximum yield of crystals.

(iv) Although many candidates have learnt this description, a large number did not describe the key points of a saturated solution – ‘no more solute can dissolve’ and ‘at a stated temperature’.

Weaker responses tended to confuse the terms *solute* and *solvent* or tended to describe saturation of organic molecules.

(v) A common incorrect answer was iron(II) nitrate or the omission of the oxidation state when the oxide or hydroxide of iron was given. A large number of candidates gave oxides or hydroxides of metals other than iron, copper being a common example.

(c) Better performing candidates were able to work their way through this structured calculation. The M_r of $FeSO_4$, was the mostly commonly seen. The mass of water, ‘152’, was often seen in working out but often did not feature on the answer line.

The importance of candidates showing working should be stressed as those candidates who did so, often picked up marks as a result of ‘error carried forward’.

(d) (i) Very few candidates knew the term for making insoluble salts from solutions of two soluble salts was ‘precipitation’. ‘Filtration’ was frequently seen, presumably as a result of candidates focussing upon **step 2** in the process.

(ii) Better performing candidates were able to recall that AgBr forms a cream precipitate.

(iii) Candidates found this ionic equation for the formation of a binary insoluble compound difficult.

It was evident that the idea of an ionic equation is not understood by many candidates. Many candidates opted to make things more difficult by giving a full equation. Others omitted ionic charges or state symbols.

(e) Candidates need to be prepared to calculate answers by working with moles rather than reacting masses.

Although there were many ways through this unstructured calculation, it was expected that candidates would determine the number of moles of $NaCl$ being formed by dividing the mass formed by the M_r of $NaCl$ ($2.34 \div 58.5$) to give 0.04 mol.

The next step is to consider the stoichiometry and to realise the number of mol of Cl_2 used was half that of $NaCl$ formed ($0.04 \div 2$) to give 0.02.

The third step was to convert the mol of Cl_2 to its volume by multiplying by 24 000.

(f) (i) It was expected that candidates would understand that conductivity of $NaCl$ was based upon the fact it is ionically bonded and when solid, the ions are in fixed positions, whereas when molten, the ions are mobile. The best responses were succinct such as, 'when solid, the ions in $NaCl$ are in fixed positions and when molten, they can move'.

'Free ions' did not gain credit as it is not clear what they are free from. 'Ions are free to move', however, is creditworthy.

Weaker responses confused electrons and ions and switched, after mentioning ions, to describe electron movement or lack of movement.

Many candidates contradicted 'ionic bonding' as they introduced covalency into their response with phrases such as '$NaCl$ has ionic bonding with strong inter-molecular forces'.

(ii) Chlorine was well known as the product at the anode, although 'chloride' was commonly seen.

(iii) Candidates found this question about the redox process at an anode ('electron loss' and 'oxidation') during electrolysis challenging.

(iv) Nearly all candidates knew that aqueous conditions would also allow electrical conductivity.

Question 3

(a) This question required candidates to state two physical properties which are found in both Group I and transition elements. Most candidates were able to state either electrical conductivity, heat conductivity or malleability.

A large number of candidates gave typical physical properties of most metals (such as high melting point, hardness and high density), which show a difference rather than similarity between these two types of metal.

Other candidates gave more than two responses, a practice which should be discouraged if only two responses are asked for.

(b) This question required candidates to state two physical properties which are different between each type of metal. Better responses focused upon the lower melting points and lower densities of Group I metals. A significant number of candidates wrote about chemical properties such as variable oxidation state and catalytic activity.

(c) (i) Most candidates were able to name hydrogen as the gas evolved when sodium reacts with water.

(ii) The identity of the ion responsible for alkalinity was known by most.

(iii) The equation for the reaction was reasonably attempted on the whole. Most took the information offered by **(i)** and **(ii)** and gave equations with sodium hydroxide as the product along with hydrogen gas.

(d) (i) Galvanising was widely known as the name of the process in which iron is coated in zinc.

(ii) Most candidates talked about sacrificial methods of rust protection rather than the obvious barrier to water / oxygen that a complete layer on the surface of the iron would afford.

(iii) This question asked how zinc blocks (rather than a complete layer of zinc) prevented rusting. Many responses indicated an understanding of rusting that goes beyond the requirements of IGCSE. At this level it was sufficient to state that zinc is more reactive than iron and therefore will corrode in preference to iron. Directions of electron flow / exchange are not needed. Candidates need to be aware that zinc does not *rust* in preference to iron.

Question 4

(a) Although the correct answer, 'hydrocarbons', was very widely known other responses such as 'carbohydrate' or 'hydrogen carbonate' were fairly regularly seen.

(b) (i) The idea that addition reactions are those which produce a single product was not widely known. Many candidates gave descriptions of addition polymerisation which, although one particular type of addition reaction, was far too narrow an answer.

(ii) Most candidates were able to draw a chain of three single-bonded carbon atoms. Only the best responses placed bromine atoms on positions 1 and 2. Common incorrect structures were 1,1-dibromopropane, 1,3-dibromopropane and monobromopropane.

(iii) The change in colour associated with the test for unsaturation was widely known.

(iv) This demanding question proved difficult for many candidates.

For those who understood that alkenes were required as the answer, the structure of but-2-ene was frequently seen, but usually accompanied by methylpropene.

Many weaker responses had structures with trivalent or pentavalent carbon atoms and many included alcohols.

(c) Many realised that HCl must be a product of this substitution reaction, but significantly fewer were able to construct the full equation.

Question 5

(a) (i) Many candidates omitted the one key condition, the presence of an acid (as a catalyst).

(ii) Most candidates knew the type of chemical change from ethanol to ethanoic acid was an oxidation.

(iii) The ability to convert the structure of ethanoic acid into a dot-and-cross diagram was done well. Candidates should understand that a single bond is one dot/cross pair and double bonds are two dot/cross pairs. All the non-bonding electrons were frequently omitted.

(b) Nearly every candidate knew that partial dissociation occurs in weak acids and full dissociation takes place in strong acids. 'High dissociation' was not credited.

Most candidates realised that two 'acidic' colours were required and that the colour of the strong acid should be more acidic than that of the weak acid. Typical successful combinations were orange and red.

Successful candidates gave effervescence as the observation and stated it was more vigorous with strong acids. Common errors were to say 'little or no effervescence' with a weak acid; failure to indicate the effervescence was greater with strong acids, or to say 'slow reaction and fast reaction' without including any observation.

(c) (i) The vast majority of candidates knew water was produced during ester formation.

(ii) Many differing irrelevant sets of conditions were seen but as long as candidates knew an acid (as a catalyst) was needed, credit was given.

(iii) Candidates needed to identify that the 3-carbon alcohol was propan-2-ol, rather than the more commonly seen propan-1-ol.

Some candidates realised an alcohol was needed, but many candidates incorrectly drew trivalent carbon atoms in their structures.

(d) (i) Candidates found it difficult to explain the meaning of the term *functional group*. Many related it to the identification of molecules or to homologous series.

(ii) Empirical formula was not clearly understood with many giving the molecular formula as well as hybrid formulae such as C_2H_4COOH.

(iii) Many responses contained errors. These included, incorrect M_r values; not appreciating the total mass of oxygen present was 32; failure to give an answer to a whole number and inverted fractions yielding answers in excess of 100% were frequently seen.

(iv) Most candidates were able to draw an ester linkage showing all the bonds, but many could get no further due to either the incorrect orientation of ester links or the omission of continuation bonds.

(v) Many candidates were able to recall that *Terylene* was a polyester. Some candidates struggled to present an unambiguous spelling of *Terylene*.

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Key messages

- Candidates should go through their plans when answering **Question 4** before writing their response. Weaker responses tend to have extra sentences inserted to cover missing points that are realised later.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then the mark will not be awarded.
- Candidates should be aware that the mark allocation is an indication of the number of valid points to be made for parts of questions.

General comments

The majority of candidates successfully completed all questions and there was no evidence that candidates were short of time. The complete range of marks was seen with some centres performing very well.

Many candidates showed familiarity with the planning task set in **Question 4**. Candidates would be well advised to plan out their answers before writing them as this will avoid steps being out of sequence.

The vast majority of candidates were able to complete tables of results from readings on diagrams and then handle the data obtained, as in **Question 2**.

Comments on specific questions

Question 1

(a) Many responses named the piece of apparatus as a beaker. A small number were confused and named a battery or electrolyte.

(b) (i) Vague references such as ‘not very reactive’, ‘does not corrode’ did not receive credit. References to being a ‘good conductor’ was a common answer, however, reference to electricity was needed.

Responses that referred to the price and availability of platinum were ignored.

(ii) Graphite/carbon were common correct answers. Other metals such as copper, iron and aluminium were rejected.

(c) Despite references to protective clothing in the stem of the question the majority of candidates used examples of this to answer the question. Few candidates realised that the safety precaution was a fume cupboard due to the toxic gas chlorine.

‘Use of a lab coat to prevent contact with acid’ and ‘keep your distance’ were common incorrect responses. Vague references to harmful and dangerous chemicals were ignored.

Question 2

(a) Almost all candidates correctly completed the tables of results from the stop-clock diagrams**.** The commonest error was varying the volume of sodium metabisulfite. Many candidates did not realise that the volume should have stayed constant at $5\,cm^3$.

(b) Most candidates plotted all points correctly. Most curves were good attempts and dot to dot straight lines drawn with a ruler were rare. Wobbly curves were not accepted.

(c) (i) Many candidates clearly indicated on their graph to show where they had read their answer from the grid.

(ii) This was generally correctly answered.

(d) Sketch lines above the original curve and lines that touched the top and/or the bottom of the original curve were not accepted.

(e) This was well answered.

(f) Vague answers referred to equal volumes of potassium iodide and sodium metabisulfite. The idea of not diluting or changing the concentration of solutions showed a lack of knowledge and understanding. Many candidates did not realise that the volume of water was changing to keep the total volume constant.

(g) The use of a burette or pipette was well known. Good response explained the use in terms of measuring volumes more accurately or compared to using a measuring cylinder.

(h) Repeating the experiments alone does not improve the reliability of the results, nor does taking a mean or average. If the results are compared and found to be similar, or if anomalies are discarded, then the results are more reliable.

Question 3

(a) The observation that the solid dissolved or a colourless solution was formed was commonly missed. Statements such as ‘a gas was given off’ are not observations.

(b) The majority of candidates identified carbon dioxide correctly.

(c) (i) The majority of candidates reported the formation of a white precipitate. A significant number thought that the precipitate would be insoluble in excess aqueous sodium hydroxide when in fact it would dissolve.

(ii) Vague references to other cations giving the same result were not credited as specific mention of aluminium was required.

(iii) This was well answered with the use of ammonia or ammonium hydroxide being recognised. Some answers referred to ammonium alone and did not gain credit.

(d) Many candidates correctly identified the presence of sodium in solid **R** from the flame test. A number did not recognise the presence of iodide ions from the result of the halide test. Reference to iodine was common.

Question 4

The complete range of marks was seen in this planning question. The quality of responses was often centre dependent.

Good responses weighed the sample of brass and used hot dilute sulfuric acid to react with the zinc component. Filtration of the residue, then washing and drying it before weighing the copper were the expected steps. Common errors were not using an excess of acid and failing to wash or dry the residue.

Weaker responses were confused and started with separate samples of zinc and copper, instead of brass.

A large number of candidates attempted to crystallise the salt from the filtrate or react the filtrate with magnesium to form zinc, not realising that subtracting the mass of copper from the initial mass of brass gave the mass of zinc. Many responses gained credit for showing how the percentage of zinc could be calculated even from a wrong method used to obtain the zinc.

A minority of candidates used the wrong method such as fractional distillation or electrolysis. These methods showed a lack of knowledge and understanding.

A significant number of candidates did not attempt the question.