CHEMISTRY

Paper 0620/12
Multiple Choice (Core)

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

General comments

Candidates found **Questions 14**, **23**, **27**, **36**, **37** and **39** to have the least demand. Candidates found **Questions 4**, **15**, **25** and **34** the most demanding. Candidates should be reminded that the correct answer must be completely correct. Some questions may have partially correct options such as option **C** for **Question 4** where the word 'halogen' makes the option incorrect.

Comments on specific questions

Question 4

Candidates found this to be one of the most challenging questions. Options **B** and **C** were both more popular than the correct answer.

Question 5

Fewer than half of the candidates answered this correctly. Option **C** was the most common incorrect answer. Candidates should be reminded that chemical reactions occur through the movement of electrons not protons.

Question 6

The majority of the candidates who performed well overall answered this correctly. Option **B** was most commonly chosen by other candidates, suggesting either a misunderstanding of the bonding in chlorine or the meaning of the word 'pair'.

Question 7

Only a third of candidates answered this correctly. The most popular answer was option **B**. This option correctly describes the structure of graphite, but it does not explain why graphite is used as an electrode.

Question 11

Most candidates chose one of the incorrect options. Option **B** was chosen by over a third of the candidates. Candidates should be reminded that the full name of the fuel cell in this syllabus is the hydrogen–oxygen fuel cell.

Question 15

This question was poorly answered, with option **C** chosen by over a third of the candidates. Confusion about the meaning of the word hydrated may have been the cause. The word hydrated should be understood as ‘with water’ and anhydrous as ‘with no water’.

Question 16

Only a small majority of candidates answered this correctly. Some candidates appeared to be guessing. Candidates needed to recognise that an alkaline gas is produced. This should have then prompted candidates to think of ammonia and its production from an ammonium salt.

Question 20

Many candidates appeared to be guessing.

Question 25

This question was not well answered. Many candidates were not able to recall the reaction of metals with water or dilute acid. Option **C** was chosen by over a third of the candidates and option **B** was chosen as often as the correct answer.

Question 26

Many candidates were unable to determine the order of reactivity from the provided information. The distribution of responses suggests that most candidates were guessing. Candidates should recall that metals will react more vigorously with steam or with a dilute acid than with cold water.

Question 34

The most common response by the candidates was option **B**. In this response, candidates confused yeast for a reactant rather than the catalyst for the reaction. Catalysts are not used up in the overall reaction and so should not appear as a reactant.

Question 38

This question proved challenging. Many candidates chose option **D** by counting the number of ‘red’ spots, without considering whether they represented the same or different dyes.

Question 39

Candidates who performed less well overall were more likely to choose option **A** or option **D**. These options would allow the formation of the pure solid salt but only if salt and water are the only substances present. In this question, it would leave a mixture of salt and sand rather than two separate solids.

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Paper 0620/22
Multiple Choice (Extended)

Question Number	Key
1	B
2	B
3	D
4	A
5	C
6	B
7	D
8	B
9	A
10	C

Question Number	Key
11	D
12	B
13	C
14	D
15	D
16	C
17	C
18	A
19	D
20	B

Question Number	Key
21	B
22	C
23	A
24	B
25	C
26	A
27	A
28	B
29	B
30	D

Question Number	Key
31	C
32	A
33	A
34	B
35	C
36	A
37	A
38	B
39	C
40	D

General comments

Overall, the candidates found this paper to be quite accessible with a small number gaining all 40 marks. Candidates found **Questions 3**, **8**, **13**, **22**, **26**, **34**, **37** and **40** to have the least demand. Candidates found **Questions 1** and **9** the most demanding. Candidates should be careful when answering questions such as **Question 7**, where the options include a correct description of the substance (here it is option **B**) but this description does not answer the question asked.

Comments on specific questions

Question 1

The first question was found to be the most challenging on this paper. Cooling curves are new to this syllabus. Candidates should recall that the temperature does not change whilst a substance changes state. Horizontal parts of the curve represent either a change of state or, as is shown here, a substance that reaches room temperature. Options **C** and **D** were most commonly chosen.

Question 7

Although most candidates answered this question correctly, some candidates chose option **B**. This is a correct description of the structure but is does not explain why graphite is used as an electrode.

Question 9

Candidates often find calculations challenging and this question was no exception. Option **B** was the most common answer to this question, where candidates assumed that all the sodium hydrogencarbonate decomposed.

Question 12

Some candidates chose option **C**. Although this is not the correct answer, candidates did show understanding of the link between the terms endothermic, exothermic and ΔH. Options **A and D** were not commonly chosen.

Question 14

For this question, only half of the candidates chose the correct answer and some candidates appeared to be guessing. A third of the candidates chose options **A** or **B**, which suggests that they did not recognise that the activation energy of a reaction does not change.

Question 18

Nearly all of the candidates who performed well overall, answered this question correctly. Overall, option **C** was the most commonly chosen incorrect answer. This option identifies the metal that is reduced rather than the substance which causes the reduction.

Question 19

This question tested recall of the formation of ammonia from ammonium salts. Candidates needed to recognise that an alkaline gas is produced. This should have then prompted candidates to think of ammonia and its production from an ammonium salt. **Option B** was the most common incorrect answer.

Question 27

This question assessed recall of metal reactivity. Almost one in four of the candidates did not recall the reaction of calcium with water and/or the reaction of magnesium with steam. Some candidates assumed that silver would react with a dilute acid and chose option **C**.

Question 35

Although options **B and D** were not chosen by many candidates, option **A** was chosen by many. Although incorrect, candidates who chose this option did recognise the correct linkages in the polymer.

Question 36

Candidates often find questions on addition polymers and their repeat units challenging. Less than half of the candidates answered this correctly with some candidates appearing to be guessing. There was no strong preference for any of the incorrect options.

Question 38

Questions on chromatography are often well answered and this was no exception for candidates who performed well overall. A third of the other candidates chose option **D**, by counting the number of 'red' spots without considering whether they represented the same or different dyes.

CHEMISTRY

Paper 0620/32
Theory (Core)

Key Messages

- Some candidates would benefit by improving their knowledge of specific chemical terms and processes and in writing specific answers.
- Other candidates would benefit by learning to write answers which are not vague and are specific to the question.
- Many candidates need more practice in analysing the stem of a question.
- Interpretation of data from tables and completion of chemical equations was generally done well.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. The standard of English was generally good. Many candidates responded to each question, although a significant minority did not respond to **Questions 6(d)(iii)**, **8(a)(ii)** and **8(c)(ii)**.

Some candidates need more practice in understanding particular chemical terms as well as remembering specific chemical reactions. For example, in **Question 1** many candidates did not appear to know the difference between atoms, ions and molecules. In **Question 2(a)** some candidates confused the terms 'filtrate' and 'residue'. In **Question 2(c)(i)** many candidates did not know the name of the main ore of iron. In **Question 2(b)(ii)** many candidates did not know the correct name of the SO_4^{2-} ion. In **Question 5(a)** the term 'properties' was not well known, with many candidates giving answers relating to electrons or charges. In **Question 6(a)(ii)** the term 'molecular formula' was not well known and in **Question 6(b)** many candidates confused the manufacture of ethanol by fermentation with its manufacture by the hydration of ethene. Some candidates did not know the difference between covalent and ionic bonding in **Question 6(d)(i)**. In **Question 6(d)(ii)** many candidates were not sure of the difference between a displayed and molecular formula. Few candidates knew the stages in the extraction of iron in the blast furnace in **Question 7(a)(ii)**. Most candidates confused the different stages, e.g. writing about slag formation when asked about the purpose of carbon monoxide. In **Question 7(a)(iii)** many candidates confused the terms 'arrangement' and 'motion' when writing about the kinetic particle theory. Others wrote about the separation between particles, which was not required for this question. The process of crystallisation was not well known in **Question 7(d)(ii)**. Other candidates made basic errors in the word equation for the reaction of sodium hydroxide with hydrochloric acid in **Question 8(c)(i)**.

In some questions, candidates did not give sufficiently precise answers to be awarded credit. For example, in **Question 2(e)** many candidates did not refer to deoxygenation of water by nitrates but wrote vague answers such as 'poisonous' or 'breathing difficulties'. In **Question 3(b)(i)** some candidates wrote vague answers such as 'factories', 'combustion' or 'harmful' rather than more specific examples such as 'car exhausts' or 'high temperature furnaces'. Similarly, in **Question 3(b)(ii)** some candidates wrote 'affects the lungs' rather than the more precise 'causes irritation to the lungs'. In **Question 3(c)** some candidates wrote answers such as 'acidic because of the nitrogen' rather than a more precise answer such as 'acidic because nitrogen is a non-metal and non-metal oxides are acidic'. In **Question 6(b)**, where the conditions for fermentation were requested, many candidates wrote vague answers such as 'pressure' and / or 'temperature'. In **Question 6(a)(iv)**, where candidates were asked how a mixture of crotyl alcohol and water are separated, many non-specific answers were given such as 'the water comes off', 'the mixture is heated at different temperatures' or 'separates the compounds at their corresponding temperatures'. Reference to the crotyl alcohol was often missing.

Some candidates need more practice in analysing the stem of a question to pick out the essential words needed to answer the question. In **Questions 2(d)** and **4(b)** some candidates gave two answers, despite being told in the stem of the question that there was only one box to tick. In **Question 2(b)(i)** some candidates did not heed the word 'negative' in the stem of the question and selected the positive ion with the lowest concentration. In **Question 2(e)** the harmful effects of oxides of nitrogen were written about instead of the harmful effects of nitrates. In **Question 3(c)** some candidates suggested that oxides of nitrogen are acidic but did not give a reason for this as asked for in the stem of the question. In **Question 4(a)** some candidates tried to write about trends in the table rather than selecting specific pieces of information. In **Question 5(a)** many candidates did not appear to understand the term 'properties' and gave unrelated answers such as 'has positive and negative ions' or 'has a metal and non-metal'. A few candidates wrote symbol equations instead of word equations in **Question 8(c)(i)**. In **Question 8(c)(ii)** many candidates did not give the formula for the hydrogen ion as requested but gave the name of an atom or molecule instead. Others wrote an equation for neutralisation.

Many candidates need to revise practical procedures and qualitative tests for specific ions. In **Question 1(d)** many candidates did not recognise the test for chromium(III) ions. In **Question 2(a)** many candidates did not draw the filter paper or filter funnel when describing filtration or placed the filter paper on top of the funnel. Others confused the residue with the filtrate or placed them in the same container, one above the other. A significant number of candidates wrote confused statements about how to prepare a dry sample of crystals from an aqueous solution in **Question 7(d)(ii)**. Some candidates did not qualify their statements and implied that they were heating to dryness. Others did not give enough information about drying the crystals. Those that did, usually suggested drastic conditions such as 'heating in an oven'.

Many candidates were able to extract information from tables and graphs, balance symbol equations and undertake simple chemical calculations.

Comments on specific questions

Question 1

Most parts of this question were answered well by the majority of candidates. The exception was part **(d)** where few candidates knew the test for chromium(III) ions.

(a) Many candidates identified the molecule containing five atoms. The commonest error was to suggest the sulfate ion, which is not a molecule. Others ignored the word five and wrote down the name of a molecule such as nitrogen or methane.

(b) Many candidates identified bromine as a diatomic molecule in Group VII of the Periodic Table. The commonest incorrect answer was the chloride ion, which is not a molecule.

(c) Some candidates recognised the chloride ion is formed when a chlorine atom gains an electron. The commonest error was to suggest K^+.

(d) Better performing candidates were able to identify the Cr^{3+} ion. The commonest errors were to suggest Cu^{2+} ions or K^+ ions. A significant number of candidates gave the formulae for molecules, the commonest of these being Br_2 and N_2.

(e) Many candidates realised that carbon dioxide is produced when calcium carbonate undergoes thermal decomposition. The commonest error was to suggest oxygen.

(f) Many candidates identified oxygen as a product of photosynthesis. The commonest error was to suggest carbon dioxide.

Question 2

Many candidates gave good answers to **(b)(i)**, **(b)(iii)**, **(c)** and **(d)**. In **(a)** many candidates did not draw filter paper inside the filter funnel or confused the residue with the filtrate. In **(b)(ii)** few candidates recognised the sulfate ion. In **(e)** many candidates gave vague answers about the harmful effects of sewage and nitrates in water.

(a) Many candidates did not draw the filter paper inside the filter funnel or drew the filter paper flat across the top of the funnel. Many candidates confused filtrate and residue, putting the residue in the collecting beaker and the filtrate in the funnel. Others drew the filtrate and residue as separate layers in the same place, e.g. in the collecting beaker. Many candidates did not label their diagrams as instructed in the question.

(b) (i) Most candidates named the negative ion with the lowest concentration correctly. The commonest error was to suggest Ca^{2+} through not reading the word 'negative' in the stem of the question.

(ii) Many candidates did not know the name of the SO_4^{2-} ion. The commonest incorrect answers included 'sulfur oxide', 'sulfur dioxide', 'sulfuric acid'. Others gave the name of the element 'sulfur'.

(iii) Many candidates did the calculation correctly. Factor of 10 errors were common e.g. 31 or 0.031.

(c) Many candidates were able to draw the electronic configuration of a sodium ion correctly. The commonest errors were to draw the structure of a sodium atom, to put an incorrect number of electrons in the inner shell or to omit the electrons altogether. The charge was generally correct, although a number of candidates suggested 11+ (the number of electrons in a sodium atom). Another common error was to suggest that the charge was 2+.

(d) Most candidates realised that oxygen is essential for aquatic life. The commonest error was to suggest 'hydrogen'.

(e) Few candidates were able to describe the harmful effects of sewage and nitrates in polluted water. There were many vague answers such as 'toxic', 'water pollution' or 'breathing difficulties' for both sewage and nitrates. Many candidates confused the nitrates with oxides of nitrogen and so gave incorrect answers such as 'acid rain', 'breathing difficulties' or 'greenhouse gases'.

Question 3

This question was well answered by some candidates; others made basic errors in **(b)(i)** and **(c)**.

(a) Many candidates completed the dot-and-cross diagram correctly. The commonest errors were to put non-bonding electrons on the hydrogen atoms, to put three electrons in the bonding overlap area or to put one or four non-bonding electrons on the nitrogen atom.

(b) (i) Most candidates gave answers which were far too vague such as 'industrial fumes' or 'factories'. Others gave the names of compounds, e.g. 'carbon dioxide'.

(ii) Some candidates gave a correct adverse effect of oxides of nitrogen related to breathing difficulties or acid rain. Others gave vague or incorrect answers such as 'affects the ozone layer', 'bad for vegetables' or 'has an effect on the lungs' (without suggesting that the effect is harmful).

(c) Few candidates linked the acidic nature of nitrogen dioxide to the position of nitrogen in the Periodic Table. Many candidates suggested that nitrogen dioxide is a basic oxide. Many candidates, who recognised that nitrogen dioxide is an acidic oxide, gave vague explanations unrelated to its non-metallic nature such as 'it has an acidic substance present in it' or 'it has an acidic pH'.

Question 4

This was the best-answered question on the question paper. Most candidates were able to identify two properties of transition elements in **(a)** and choose an insoluble metal chloride in **(b)**. In **(c)(ii)** few candidates were able to give a suitable explanation of how the diagram in **(c)** shows that the reaction is exothermic. Nearly all candidates performed well in **(d)** and **(e)**.

(a) Most candidates gave two suitable properties of transition elements. The commonest error was to suggest the elements themselves are coloured rather than the compounds. The commonest errors in selecting the two transition elements were to suggest **C** and **D** or **B** and **C** rather than **B** and **D**. A few candidates tried to write about trends in the table, e.g. 'the boiling point decreases as you go down'.

(b) Most candidates realised that silver chloride is insoluble in water.

(c) (i) Most candidates completed the reaction pathway diagram correctly. The commonest errors were to write the reactants on the right and the products on the left, to write chlorine next the arrow or to not write the formulae on the lines.

(ii) Most candidates did not refer to the reactants and the products. The best answers stated that 'the energy of the reactants is greater than the energy of the products'. The commonest error was to try and define the term exothermic rather than referring to the diagram.

(d) Nearly all the candidates gave the correct order of reactivity of the metals. The commonest error was to reverse the positions of iron and nickel. A significant number of candidates wrote the word 'metal' in one of the boxes rather than the name of a metal. Candidates should be advised to learn to distinguish between the heading in a table and the contents of the table.

(e) A majority of the candidate gained full credit for the calculation. The commonest error was to use the incorrect number of atoms, e.g. 15×31 for phosphorus.

Question 5

This question was well-answered by many candidates. The exception was **(a)** where few candidates knew the typical properties if an ionic compound.

(a) Many candidates did not understand the word 'properties' in the stem of the question and wrote about positive and negative ions, bonding or metals and non-metals. Others gave the names of specific substances, e.g. 'lead' or 'graphite'. The best answers referred to high melting points and conduction of electricity when molten or in aqueous solution. A number of candidates disadvantaged themselves by just writing 'conducts electricity' as an unqualified statement.

(b) (i) Many candidates gave the correct products at each electrode. The commonest error was to suggest that potassium is formed at the positive electrode and iodine at the negative electrode. Other common errors included 'iodide' or 'potassium iodide' at the positive electrode. A considerable number of candidates did not read the word molten in the stem of the question and suggested that hydrogen is formed at one of the electrodes.

(ii) Many candidates knew that the positive electrode is called the anode. Common errors were 'cathode', 'cation', 'platinum' or 'graphite'.

(c) A majority deduced the correct number of protons and neutrons. Some candidates suggested 52 or 54 protons, (a confusion with the possible number of electrons). Others suggested 73 or 75 for the number of neutrons. Another common error was to suggest 127 (the mass number) for either the number of protons or number of neutrons.

(d) (i) Many candidates balanced the equation correctly. The commonest error was to write the formula of iodine as 2I. A significant number of candidates omitted iodine altogether, replacing it with chlorine or some other element.

(ii) Many candidates recognised that the reaction is a displacement reaction. The commonest error was to suggest 'neutralisation'.

(iii) The best answers stated the colour of chlorine as 'yellow-green' or 'light green'. The commonest incorrect answers were 'yellow' or 'colourless'. Many candidates appeared to guess the colour, with 'orange' and 'blue' frequently seen.

Question 6

This was one of the least-well answered questions on the paper, although **(a)(i)(ii)(iii)**, **(c)** and **(d)(iv)** were generally well answered. In **(a)(iv)** many candidates did not write specifically enough when describing how to separate crotyl alcohol from water by distillation. In **(b)** many did not know the conditions for fermentation. In **(d)(i)** only the better performing candidates were able to name the type of bonding in alkanes. In **(d)(iii)** few named chlorine as the substituent.

(a) (i) Some candidates recognised the OH functional group. The commonest errors were to include the carbon atom adjacent to the OH group, to circle the H and OH or to circle the C=C group.

(ii) Most candidates identified the C=C group as being responsible for unsaturation. The commonest incorrect answer was to select the OH group.

(iii) Better performing candidates deduced the molecular formula correctly. Others wrote structural formulae or wrote a formula showing the OH group e.g. 'C_4H_7OH'. Many candidates did not count the number of atoms correctly and gave answers such as 'C_5H_6O'.

(iv) Better performing candidates referred to the water having a lower boiling point than crotyl alcohol and therefore boiling off first. Many answers were too vague to gain credit, e.g. 'separates them at the corresponding temperatures' or 'water is lower than crotyl alcohol' (without mentioning boiling point). Many candidates just referred to the water boiling off without mentioning that the crotyl alcohol remains in the flask. Others mentioned condensation without mentioning where the condensation occurs. Others confused simple distillation with the fractional distillation of petroleum or wrote about separation by filtration.

(b) Few candidates were able to describe two conditions for the manufacture of glucose by fermentation. Better performing candidates suggested 'yeast' or gave a suitable temperature. Few candidates suggested both. Common errors included 'presence of oxygen', 'high temperature' or 'high pressure'. A considerable number of candidates suggested 'temperature' without a qualification. Others gave temperature ranges which did not correspond to those in the syllabus.

(c) Many candidates selected the correct general formula. The commonest error was to suggest the general formula for alkanes rather than alkenes.

(d) (i) Better performing candidates realised that the type of bonding was covalent. The commonest errors were to suggest either 'single bonding' or 'ionic bonding'.

(ii) Some candidates drew the displayed formula of ethane correctly. Others did not gain credit because they wrote a molecular formula as well as a displayed formula, often with an arrow between the two, so that it was not clear which formula was being selected. Candidates should be advised to cross out the type of formula which is incorrect. Other common errors were to draw the structures of methane or ethene. Some candidates drew single bonded structures with too few hydrogen atoms.

(iii) Only a few candidates knew that chlorine reacts with alkanes (in the presence of light). Common errors were 'oxygen', 'alkenes' or 'nitrogen'. Other candidates suggested processes rather than names of chemicals, e.g. 'cracking' or 'catalysis'.

(iv) Many candidates balanced the oxygen correctly. The commonest error here was to write HO_2 rather then $2O_2$. Another very common error was to suggest CO or C as a product.

Question 7

This was one of the least-well answered questions on the paper. Few candidates knew about the extraction of iron in **(a)(ii)** or gave precise enough answers about the arrangement and motion of the particles in a liquid in **(a)(iii)**. In **(c)(i)** (definition of hydrated) the majority of the candidates gave answers which were too vague. In **(d)(ii)** only the better performing candidates described how dry crystals of iron(II) chloride can be made. Parts **(b)** (oxidation of iron), **(c)(ii)** (conditions for rusting) and **(d)(i)** (separation of iron from a solution) were generally well answered.

(a) (i) Many candidates knew that hematite is an ore of iron. The commonest error was to write the formula of iron oxide instead of giving the name of the ore. A significant number of candidates suggested ‘bauxite’ instead of hematite.

(ii) Many candidates need to revise the details of the extraction of iron in the blast furnace. The production of carbon monoxide was not well known. The commonest error was to suggest that carbon monoxide is formed directly by incomplete combustion. Few candidates mentioned that the oxygen reacts with the coke to form carbon dioxide as a first step. The role of carbon monoxide as a reducing agent was better known but many confused this step with the formation of slag or with the production of carbon dioxide. The role of calcium carbonate was not well known. Few candidates realised that calcium carbonate decomposes to calcium oxide before reacting with silicon dioxide. Many candidates suggested, incorrectly, that calcium carbonate ‘is a catalyst’. Others gave vague statements about the ‘extraction of carbon’ or ‘reaction with carbon dioxide’.

(iii) Some candidates gained some credit for describing the arrangement and motion of the particles in a liquid. Many candidates wrote about motion or proximity of particles instead of arrangement. A significant number of candidates gave answers relating to bulk properties of liquids, e.g. ‘they flow over a surface’. The motion of the particles was generally better explained. Common errors were to suggest that ‘the particles vibrate’ (without mentioning them sliding over each other) or ‘they collide with each other’ (which does not distinguish the motion of liquid particles from those of a gas).

(b) Many candidates were able to describe how the equation shows that iron is oxidised. Others just gave a definition of oxidation without referring to the equation. The best answers referred to the iron, e.g. ‘the iron gains oxygen’. Other common errors included reference to the water rather than the iron, repeating the equation or just mentioning that iron oxide is formed.

(c) (i) Many candidates wrote vague statements when defining the term ‘hydrated’. The commonest errors were to suggest ‘water is present’, dissolved in water’, ‘liquid’ or absorbs water’.

(ii) The majority of the candidates knew the conditions for rusting. The commonest error was to suggest ‘hydrogen’ instead of oxygen.

(d) (i) Many candidates recognised that filtration is used to separate a solid from an aqueous solution. The commonest errors were ‘distillation’, ‘crystallisation’ or ‘titration’. A few candidates did not mention a physical method, suggesting a chemical method instead, e.g. ‘react it with hydrochloric acid’.

(ii) Better performing candidates suggested that the solution is heated to the point of crystallisation and then left to cool. Most answers were vague or incorrect, e.g. ‘heat to evaporate the solvent’ or ‘evaporate the water’. Few candidates correctly referred to the drying of the crystals but suggested methods which are too drastic, e.g. ‘heat in an oven’ or ‘put in a desiccator’. Others wrote vague statements such as ‘leave to dry’.

Question 8

This question was answered well by many candidates. Many candidates performed particularly well in **(a)(i)**, **(b)(i)**, **(c)(i)** and **(c)(iii)**. In **(a)(ii)** many candidates need to improve their graphical skills and consider which chemical is limiting (not in excess) and therefore is used up during the reaction. In **(c)(ii)** few candidates knew that the H^+ ion is present in all acids. In **(c)(iv)** many candidates appeared to guess the colour of methyl orange in alkaline solution.

(a) (i) The majority of the candidates deduced the volume of hydrogen released after 2 minutes. The commonest errors were to suggest '17 cm^3' or '37 cm^3'. Others suggested '44 cm^3', the point where the line begins to flatten off.

(ii) Many candidates drew a line with a steeper initial gradient. Others did not draw the line for the initial gradient accurately enough and started some distance from the (0,0) point or drew a vertical line from 0 to 10 cm^3. Most candidates did not note that the hydrochloric acid was in excess and consequently drew the line for the final volume well above 44 cm^3. A considerable number of candidates drew lines which went well above 44 cm^3 and then went back to 44 cm^3. Candidates should be advised to draw their line with more care.

(b) (i) Most candidates realised that the rate of reaction decreases when using larger pieces of iron. The commonest errors were to suggest that 'the rate increases' or that 'it takes longer' (which is about time rather than rate).

(ii) Many candidates realised that the rate of reaction decreases when the temperature decreases. The commonest errors were to suggest that 'the rate increases' or that 'it takes longer' (which is about time rather than rate).

(c) (i) The majority of the candidates were able to complete the equation correctly. The commonest errors were to suggest 'sodium hydrochloric' or 'sodium hydroxide' instead of 'sodium chloride' or 'hydrogen' instead of 'water'.

(ii) Better performing candidates knew the formula for the ion present in all acids. Some candidates wrote the name rather than the formula. Common errors included OH^-, HCl or H^-.

(iii) Most candidates chose the correct pH value for an aqueous solution of sodium hydroxide. The commonest error was to suggest pH 4.

(iv) Some candidates knew that methyl orange is yellow in alkaline solution. The commonest errors were to suggest 'orange' or 'red'. Other candidates appeared to guess the colour as a wide range of incorrect colours were seen, e.g. 'purple', 'blue' or 'colourless'.

CHEMISTRY

Paper 0620/42
Theory (Extended)

Key messages

Candidates need to be careful in the use of subscripts in formulae as well as upper/lower case in symbols.

When drawing displayed formulae of organic compounds, all bonds should be drawn and shown with the correct valency of the atoms. Divalent hydrogen atoms and pentavalent carbon atoms were seen in **Question 5(h)(iii)**.

Calculations were generally done well but candidates who performed less well overall often did not show their working.

General comments

The overall standard was very high, but this was the first examination following a syllabus change and it was noticeable that some candidates were not familiar with some of the newer content of the syllabus.

The rubric of questions must be followed. For example, if a single answer is asked for then two (or three) answers should not be given, as incorrect statements may contradict correct answers.

In extended questions such **Question 3(b)(v)**, candidates should be advised to present their answers in short sentences or using bullet points. Longer sentences lead to repetition of some facts which often show contradictions to earlier comments.

Comments on specific questions

Question 1

(a) Most candidates stated carbon dioxide, although methane was a common incorrect answer.

(b) The vast majority of candidates were able to give the percentage of nitrogen as 78%.

(c) This question was the least well known part of **Question 1**. Syllabus learning objective **10.3.4** states: '*reducing emissions of sulfur dioxide by using low-sulfur fuels and flue gas desulfurisation with calcium oxide*'. Some candidates gave calcium oxide as an answer; many others were not able to provide a suitable answer.

(d) The use of a catalytic converter was well known by most candidates.

(e) (i) Most candidates opted for CH_4 as the gas which diffuses quickest. Many thought it was CO, presumably because it has the fewest atoms in a molecule.

(ii) The majority of candidates correctly identified that having the lowest molecular mass was the reason why a particular gas should diffuse quickest. Incorrect responses included 'lightest gas' and 'lowest relative atomic mass'.

(f) Many candidates gave answers beyond the scope of an IGCSE chemistry question. Syllabus learning objective **10.3.3(b)** states: '*State the adverse effect of these air pollutants, limited to carbon monoxide: toxic gas*'.

Some gave answers relating to haemoglobin that, although technically correct, contained an irrelevant level of biological detail.

(g) This question was well answered. Candidates occasionally gave water as one of the products.

(h) Most candidates could recall the covalent bonds and the correct number of non-bonding electrons in a molecule of carbon dioxide.

Question 2

(a) Most candidates knew that the bonding in these elements was metallic, although ionic was a frequently seen incorrect response.

(b) (i) Most candidates were able to correctly describe the test (lighted splint) and the positive result (pop). Candidates who performed less well often used vague terms such as 'splint test' or erroneously wrote 'glowing splint'.

(ii) Most candidates opted for '14' as the pH of a strong alkali. If candidates give a range, then both the lower and upper numbers must fall within the range of answers accepted.

(iii) Most candidates knew universal indicator was the correct substance used to confirm the pH. Many candidates also opted to give a second, incorrect, answer such as litmus or methyl orange.

(iv) A significant number of candidates gained full credit for this difficult question. Errors included: 'Aq' for 'aq'; 'H_2O(aq)'; forgetting to balance the equation, as well as incorrect formulae such as Na_2O and $Na(OH)_2$.

(c) (i) Isotope was almost universally known.

(ii) The majority of candidates gained full credit. Occasionally, the neutron row was seen as 6 and 7.

(iii) Most candidates realised that isotopic mass $\times$ abundance was significant and once calculated, these candidates were able to determine the average of this value to one decimal place.

(d) This question discriminated well. The most common error was omitting the fourth electron shell of K. Candidates who performed less well typically only gave the correct charges.

Question 3

(a) This question relied upon knowledge of the new syllabus. Syllabus learning objective **6.3.6** states: '*State the sources of the hydrogen (methane) and nitrogen (air) in the Haber process'.*
Air was well known; methane, far less so.

(b) (i)(ii) Both these questions relied upon knowledge of the new syllabus. Syllabus learning objective **5.1.4** states: '*State that the transfer of thermal energy during a reaction is called the enthalpy change, ΔH, of the reaction. ΔH is negative for exothermic reactions and positive for endothermic reactions'.*
The meaning of ΔH was not well known – vague terms such as 'energy change' were often seen. The relevance of the negative value as an indicator of an exothermic reaction was hardly ever seen.

(iii) The temperature and identity of the catalyst were well known, but the value of the pressure, in kPa, was less well known. Syllabus learning objective **6.3.7** states: '*State the typical conditions in the Haber process as 450 °C, 20 000 kPa / 200 atm and an iron catalyst'*. 200 000 kPa or 0.2 kPa were the most frequent errors.

(iv) Most candidates coped well with predicting the effect of changing the conditions.

(v) Stating that the energy increases was commonly achieved by candidates. Many candidates also stated that the frequency of collisions increases – often seen as 'more collisions per unit time'. Candidates who performed less well tended to simply state there were 'more collisions' without reference to frequency. Fewer candidates stated that a greater percentage of particles have energy greater than the activation energy. Many candidates wrote phrases such as 'particles have energy greater than activation energy' suggesting all particles had energy greater than activation energy. Some candidates erroneously stated activation energy is reduced.

(c) (i) 'H_2SO_4' was well known. Some candidates did not follow the instruction in the question and gave the name and not the formula.

(ii) The use of ammonium sulfate as a fertiliser was well known.

(iii) Where candidates did not produce the correct answer, credit could be awarded for a correctly calculated relative formula mass, but often this was left as an uncalculated sum such as $(14 + 1 \times 4) \times 2 + 32 + 16 \times 4$.

Question 4

(a) (i) Most candidates knew brass consisted of copper and zinc, although tin, iron and lead were frequent alternatives to iron.

(ii) The term alloy was almost universally known

(b) (i) The correct answer of ductility was the most often seen response, although 'malleability' was also seen. It was not uncommon to see both responses with one being crossed through, showing uncertainty amongst many candidates.

(ii) This was almost universally correct. A small minority assumed ions were responsible for the passage of electricity in metals.

(c) (i)(ii) Most candidates were able to correctly identify one additional physical property and chemical property of metals.

(d) (i)(ii)(iii)
Candidates struggled with **(i)** and **(iii)**, where various incorrect terms and formulae were seen. Syllabus learning objective **7.3.5** states: '*Define the term water of crystallisation as the water molecules present in hydrated crystals, including $CuSO_4 \cdot 5H_2O$*'.

(e) (i) Many candidates struggled with the term 'class of oxide'. Syllabus learning objective **7.2.1** states: '*Classify oxides as acidic, including SO_2 and CO_2, or basic, including CuO and CaO, related to metallic and non-metallic character*'.

(ii) Candidates struggled to give the key detail that the Roman numeral (II) in the name copper(II) oxide means that the oxidation number of copper is +2. Syllabus learning objective **6.4.1** states: '*Use a Roman numeral to indicate the oxidation number of an element in a compound*'.

Vague responses such as 'its oxidation number is 2' received no credit. Better performing candidates knew that the oxidation number refers to an element within a compound and that oxidation numbers are either positive or negative integers.

Many candidates attempted to write about valency. 'Valency' is not a syllabus term for IGCSE Chemistry.

(iii) Where candidates did not produce the correct answer, they could gain credit for a correctly calculated relative formula mass, but often this was left as an uncalculated sum.

(iv) Most candidates did not convert the number of moles of solid (copper(II) nitrate) into moles of gaseous products, and multiplied a stated number of moles of solid by 24.0. Thus 0.02×24.0 gained no credit.

(v) Often only the formulae of the products was correct and there was no attempt to balance the equation. Incorrect techniques were also used, such as Al_2 for balancing the equation.

Question 5

(a) Most candidates explained that members of a homologous series have similar chemical properties due to having the same functional group. Many then also stated the reason was due to the same general formula.

(b) Almost all candidates answered this question correctly.

(c) Syllabus learning objective **11.1.2(d)** states: '*Write and interpret general formulae of compounds in the same homologous series, limited to carboxylic acids, $C_nH_{2n+1}COOH$'.* The often seen $C_{n-1}H_{2n-1}COOH$ received no credit. Other candidates had incorrect use of subscripts such as C_nH_{2n}+1COOH.

(d) The name of the unbranched isomer was often known but many candidates drew the displayed formula incorrectly because of omitting the O–H bond.

(e) (i) Most candidates were able to complete the equation. Candidates who performed less well struggled to reproduce the molecular formulae of propane and propene.

(ii) Catalytic cracking was almost universally known.

(f) (i) Many candidates found this question challenging. The most common incorrect response was a nine-carbon saturated hydrocarbon, with or without continuation bonds. Also seen frequently were three sets of three-carbon saturated hydrocarbons, often in brackets with continuation bonds or without brackets and joined by divalent hydrogen atoms. Most candidates who gave the correct structures did not draw in the C–H bonds in the methyl group.

(ii) This was known by most candidates.

(g) (i)(ii) Most candidates could name sodium propanoate in **(i)** but the formula of the anion in **(ii)** proved difficult.

(h) (i) The majority of candidates correctly opted to identify an acid catalyst. Common incorrect responses included catalysts from other parts of the syllabus, e.g. iron and nickel.

(ii) The name of the ester was known by most candidates. The most common error was the misspelling of 'propanoate' as 'propanote'.

(iii) Most candidates were able to draw the displayed formula of ethyl propanoate.

CHEMISTRY

Paper 0620/52
Practical Test

Key messages

It is essential that centres make up solutions and provide apparatus in accordance with the details contained in the Confidential Instructions. If there is difficulty in obtaining some substances, then the centre should contact Cambridge Assessment for advice.

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

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 an HB pencil. Lines of best fit should be smooth curves or ruler-drawn straight lines; they should not wobble from point to point. Candidates will need to decide if the points lie on a straight line or a curve.

In the qualitative analysis question (**Question 2**), where a question states 'Test any gas produced' then candidates are expected to test the gas and record the details for the gas test that gave a positive result. Candidates are expected to use the term 'precipitate' when describing the formation of solid from a reaction between two solutions; if, when two solutions are mixed, the product becomes cloudy and opaque, then a precipitate has been formed.

General comments

The vast majority of candidates successfully attempted all of the questions. There was no evidence of candidates running short of time. The paper was generally well answered, with very few blank spaces.

In **Question 1**, most candidates obtained results that were in line with those expected and they obtained results that showed a clear trend.

In answering the planning question (**Question 3**), 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. 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; this will not be awarded just for a name in a list of other apparatus.

Comments on specific questions

Question 1

(a) The vast majority of candidates successfully completed the investigation and recorded results for all five experiments. The most common error was not to record data from a given item of apparatus to a consistent number of decimal places. The volume of water used in Experiment 1 was printed in the table as '8.0' and so ALL volumes of water should have been recorded to 1 decimal place. Candidates should also be reading apparatus to the nearest half scale division and so temperatures should ideally have been recorded to the nearest 0.5 °C.

(b) The vast majority of candidates were able to select an appropriate scale and plot the five points accurately. When drawing a line of best fit, candidates should remember that a best-fit line should be a single, thin, smooth straight-line or curve and that the line does not need to coincide exactly with any of the points. Where there is scatter evident in the data, a roughly even distribution of points either side of the line over its entire length is expected. If the 'best-fit straight line' has the points at either end of the line on one side and the points nearer the middle of the line on the other side, then that should suggest that the line should be a curve.

(c) The vast majority of candidates were able to draw an appropriate extrapolation for the line they had drawn in **(b)** and correctly read a value from the line. Some candidates did not show working on the graph to indicate where the value had been read from the graph.

(d) Most candidates were able to substitute the values from Experiment 1 into the provided equation to calculate a solubility. A few candidates incorrectly rounded their answers.

(e) Answers had to include the direction of change of both solubility and temperature – such as 'as the temperature increases the solubility increases'. Some candidates did not gain credit as they did not give the direction of change for both variables. Some candidates ignored the question and tried to give a relationship between solubility and the volume of water rather than temperature.

(f) (i) The vast majority of candidates correctly referred to the higher accuracy of a burette compared to a measuring cylinder.

(ii) The use of a volumetric pipette is a new introduction to the syllabus and many candidates are not yet familiar with it. Candidates that performed well were able to correctly state that a volumetric pipette can only measure a single volume while a burette can measure variable volumes. Many of the answers suggested that candidates were thinking of dropping or Pasteur pipettes. Some candidates referred to the risk of chemicals entering their mouth when filling a volumetric pipette; it should be noted that when a volumetric pipette is used, a safety pipette filler must always also be used.

(g) Better performing candidates correctly stated that if the water is added in 1.0 cm^3 portions then fewer results would be obtained and that fewer points on the graph would cause problems when drawing a line of best fit. It was a common error for candidates to state that the results would be less accurate – this cannot be the case as the experiment and apparatus would be the same but with the points at 8.5 cm^3 and 9.5 cm^3 missing.

(h) Many candidates correctly stated that the ammonium chloride could not be fully dissolved in the lower volume of water. However, some gave vague answers, such as 'it is not enough water', which did not gain credit.

Question 2

(a) The vast majority of candidates obtained an orange-red flame colour. A small number of candidates recorded observations, such effervescence or precipitates forming, that could not have been obtained from a flame test.

(b) Many candidates correctly noted the formation of a white precipitate which remained when excess aqueous sodium hydroxide was added. A few candidates just noted that the mixture became 'cloudy white'; this is not sufficient, and the term 'precipitate' should be used.

(c) (i) Some candidates did not notice that two marks were available and so did not realise that a single observation would not be sufficient. As the question stated 'test any gas produced', candidates were expected to record the result of a positive test for the gas (damp red litmus paper turning blue). Credit was also awarded for stating either that effervescence was observed or that the gas produced had a pungent smell. Some candidates recorded positive gas test results that were not possible given the reactants.

(ii) Most candidates correctly stated that the gas produced was ammonia.

(d) The majority of candidates stated that no visible change was seen. Some candidates reported a positive test for a halide ion, suggesting that they expect all tests to have a positive result; negative test results are useful as they tell us what a substance is not.

(e) The majority of candidates correctly reported the formation of a white precipitate.

(f) The majority of candidates were able to identify solution **C** as calcium nitrate.

(g) The vast majority of candidates recorded an acceptable pH value between 1 and 3 for the strongly acidic solution. A small number of candidates reported pH values of 7 or above, suggesting that they had tested the incorrect solution.

(h) The majority of candidates correctly reported the formation of a white precipitate.

(i) Better performing candidates gained full credit. However, some candidates did not notice that two marks were available and so did not realise that a single observation would not be sufficient. As the question stated 'test any gas produced', candidates were expected to record the result of a positive test for the gas (limewater turning milky). Credit was also awarded for stating that effervescence was observed.

(j) While the majority of candidates correctly identified the sulfate ion, far fewer candidates also identified the hydrogen ion. A common error was to state that carbonate ions were present in solution **D**, presumably because carbonate ions can react to form carbon dioxide and those candidates forgot that carbonate ions had been added to solution **D** to form the carbon dioxide in **(i)**.

Question 3

This question required candidates to plan an investigation to place three metals in order of reactivity. The information within the question guided candidates to use either temperature change or the production of gas to help deduce the order of reactivity. Many very good answers were seen.

Candidates were instructed to make it clear how their investigation would be a fair test. Most candidates correctly tried to control the mass of metal used and the volume of acid ('amount' is not an acceptable alternative term for 'volume') but did not consider the concentration of the acid or the temperature of the acid.

The most common method was to measure the volume of gas produced during the reaction. It should be noted that a beaker is not an appropriate reaction vessel to fit with a bung and delivery tube. The volume of gas collected at the end of the reaction is a function of the number of moles of metal reacting and not the reactivity of the metal, hence the volume of gas needed to be measured after a fixed time or the time to make a fixed volume of gas needed to be measured.

Other common methods were measuring the temperature change during the exothermic reaction and measuring the time taken for the reaction to be complete (indicated by effervescence stopping).

Some candidates did not make it clear how the results of their investigation would indicate the order of reactivity. Vague statements such as 'use the results to determine the order of reactivity' were not creditworthy.

CHEMISTRY

Paper 0620/62
Alternative to Practical

Key messages

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

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 an HB pencil. Lines of best fit should be smooth curves or ruler-drawn straight lines; they should not wobble from point to point. Candidates will need to decide if the points lie on a straight line or a curve.

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 credit will not be awarded.

In the qualitative analysis question (**Question 3**), where a question states ‘Any gas produced is tested’ then candidates are expected to state the observations made in the positive test for the gas.

General comments

This is the first session in which the **Notes for use in qualitative analysis** have been provided on the Alternative to Practical paper. As expected, the performance of candidates on the qualitative analysis question, **Question 3**, showed a marked improvement when compared to previous years.

The vast majority of candidates successfully attempted all of the questions. The paper was generally well answered, with very few blank spaces.

When giving a numerical answer, such as in **Question 3(e)**, if candidates give a range, then both the lower and upper numbers given must fall within the range of answers accepted. Hence, unless asked for in the question, it is better to give a single value rather than a range.

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. 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; this will not be awarded just for a name in a list of other apparatus.

Comments on specific questions

Question 1

(a) The majority of candidates were able to give an appropriate name for **A**. However, come candidates gave inappropriate names, such as ‘evaporating basin’ or vague names such as ‘container’; these were not credited. It was evident that some candidates did not look carefully at the diagram and tried to name the tube in which the gas was being collected.

(b) The vast majority of candidates were able to explain that the reaction was faster because the total surface area of the small pieces was larger than that of a single large piece. Some candidates gave answers that repeated the question and stated that small pieces make it react faster.

(c) (i) As expected, most candidates were able to state that a Bunsen burner should be used to heat the long-chain alkane and catalyst. A few candidates suggested inappropriate heating devices such as a water-bath (which would not get hot enough) or a match.

(ii) While most candidates drew arrows to show that the long-chain alkane and the catalyst should be heated, some candidates drew arrows carelessly and they did not point to the parts of the tube that needed heating. Some candidates heated the trough or the delivery tube and so did not gain credit.

(d) The majority of answers suggested that many candidates were not familiar with making and collecting gases. As the reaction tube and delivery tube are full of air at the start, as the apparatus is heated the air expands and the first few bubbles of gas collected are air. Even once the reaction starts, the gases made will push air out of the apparatus. A common error was to state that the gas collected was the long-chain alkane being heated. However, the long-chain alkane being heated was a liquid soaked into mineral wool so that after passing into the water in the trough it would condense back into a liquid. Even if a gaseous alkane had been collected it must have been formed by cracking the long-chain alkane, however, this would have resulted in the formation of alkenes which would have reacted with the bromine water.

(e) Some candidates were clearly familiar with the idea of 'suck-back', where the cooling gas contracts and so reduces the pressure in the reaction tube resulting in water being pushed into the reaction tube via the delivery tube causing the reaction tube to be cooled rapidly and so crack. However, many candidates thought other reactions would happen or that the experiment would become 'inaccurate', even though nothing was being measured.

Question 2

(a) The vast majority of candidates were able to complete the table using the information in the descriptions of the experiments and the thermometer diagrams. The most common errors were to not read and record the thermometer diagrams to the nearest half-scale division as was expected or to use an inconsistent number of decimal places for the quantities recorded in the table.

(b) The vast majority of candidates were able to select an appropriate scale and plot the five points accurately. However, the majority drew a straight line through the points, despite the fact they were on a curve. When drawing a line of best fit candidates should remember that a best-fit line should be a single, thin, smooth straight-line or curve and the line does not need to coincide exactly with any of the points. Where there is scatter evident in the data, a roughly even distribution of points either side of the line over its entire length is expected. If the 'best-fit straight line' has the points at either end of the line on one side and the points nearer the middle of the line on the other side, then that should suggest that the line should be a curve.

(c) The vast majority of candidates were able to draw an appropriate extrapolation for the line they had drawn in **(b)** and correctly read a value from the line. Some candidates did not show working on the graph to indicate where the value had been read from the graph.

(d) Most candidates were able to substitute the values from Experiment 1 into the provided equation to calculate a solubility. A few candidates incorrectly rounded their answers.

(e) Answers had to include the direction of change of both solubility and temperature – such as 'as the temperature increases, the solubility increases'. Some candidates did not gain credit as they did not give the direction of change for both variables. Some candidates ignored the question and tried to give a relationship between solubility and the volume of water rather than temperature.

(f) (i) The vast majority of candidates correctly referred to the better accuracy of a burette compared to a measuring cylinder.

(ii) The use of a volumetric pipette is a new introduction to the syllabus and many candidates are not yet familiar with it. Better performing candidates were able to correctly state that a volumetric pipette can only measure a single volume while a burette can measure variable volumes. Many of the answers suggested that candidates were thinking of dropping or Pasteur pipettes. Some candidates referred to the risk of chemicals entering their mouth when filling a volumetric pipette. It should be noted that when a volumetric pipette is used, a safety pipette filler should always also be used.

(g) Better performing candidates correctly stated that if the water is added in 1.0 cm^3 portions then fewer results would be obtained and that fewer points on the graph would cause problems when drawing a line of best fit. It was a common error for candidates to state that the results would be less accurate – this cannot be the case as the experiment and apparatus would be the same but with the points at 8.5 cm^3 and 9.5 cm^3 missing.

(h) Many candidates correctly stated that the ammonium chloride could not be fully dissolved in the lower volume of water. However, some gave vague answers, such as 'it is not enough water', which did not gain credit.

Question 3

(a) The vast majority of candidates were able to give the correct result of the flame test, although a small minority did not take advantage of the **Notes for use in qualitative analysis** on the last two pages of the question paper.

(b) The vast majority of candidates were able to give the correct result for the addition of aqueous sodium hydroxide to solution **C**. A small minority did not take advantage of the **Notes for use in qualitative analysis** on the last two pages of the question paper.

(c) While many candidates gave a correct test for the ammonia gas produced, some merely stated that the gas made was ammonia and gave no observations from an appropriate gas test to support that statement.

(d) Most candidates correctly stated that there would be no reaction or that no change would be seen. A small minority of candidates seemed to think, incorrectly, that if a test is carried out then there must be a positive result.

(e) The vast majority of candidates were able to give an appropriate pH value for a strongly acidic solution. However, a small number of candidates gave a range of pH values and where that range was not wholly within the permitted range, credit could not be awarded.

(f) Almost all candidates correctly identified the gas as carbon dioxide.

(g) While the majority of candidates correctly identified the sulfate ion, far fewer candidates also identified the hydrogen ion. A common error was to state that carbonate ions were present in solution **D**, presumably because carbonate ions can react to form carbon dioxide and those candidates forgot that carbonate ions had been added to solution **D** to form the carbon dioxide.

Question 4

This question required candidates to plan an investigation to place three metals in order of reactivity. The information within the question guided candidates to use either temperature change or the production of gas to help deduce the order of reactivity. Many very good answers were seen.

Candidates were instructed to make it clear how their investigation would be a fair test. Most candidates correctly tried to control the mass of metal used and the volume of acid ('amount' is not an acceptable alternative term for 'volume') but did not consider the concentration of the acid or the temperature of the acid.

The most common method was to measure the volume of gas produced during the reaction. It should be noted that a beaker is not an appropriate reaction vessel to fit with a bung and delivery tube. The volume of gas collected at the end of the reaction is a function of the number of moles of metal reacting and not the reactivity of the metal, hence the volume of gas needed to be measured after a fixed time or the time to make a fixed volume of gas needed to be measured.

Other common methods were measuring the temperature change during the exothermic reaction and measuring the time taken for the reaction to be complete (indicated by effervescence stopping).

Some candidates did not make it clear how the results of their investigation would indicate the order of reactivity. Vague statements such as 'use the results to determine the order of reactivity' were not creditworthy.