CHEMISTRY

Paper 0620/11
Multiple Choice

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

General comments

Candidates performed quite well on this paper. **Questions 1**, **2**, **7**, **12**, **15**, **24**, **25**, **28**, **35** and **37** proved particularly straightforward with the vast majority of candidates choosing the correct response. **Questions 26**, **30** and **34** proved to be difficult with only a minority of candidates choosing the correct response.

The following responses were popular **wrong** answers to the questions listed.

Comments on specific questions

Question 5

Response **D**. Candidates chose the total number of electrons rather than the number in the outer shell.

Question 6

Response **C**. Candidates chose the alternative where only one atom of each element was presumably assuming that this meant that all electrons were used.

Question 9

Response **B**. Candidates did not fully understand electrolysis assuming that sodium would be produced from an aqueous solution.

Question 10

Response **B**. Candidates appreciated that a copper salt needed to be used but chose the wrong electrode for its deposition.

Question 18

Response **C**. This response was more popular than the correct answer. Candidates knew that the pH would rise as an alkali was added, but did not read the question fully and realise that an excess of alkali was added.

Question 23

Response **B**. Candidates considered the density of helium rather than its reactivity and incorrectly thought that helium was less dense that hydrogen.

Question 30

Response **B**. This response was more popular than the correct answer. Candidates did not realise how little carbon dioxide is in the air. This is a common error.

Question 32

Response **A**. Candidates partially remembered the test for ammonium salts but opted to add acid rather than alkali.

Question 34

Response **B**. This response was more popular than the correct answer. Candidates did not know that limestone is heated to make lime.

Question 36

Response **B**. Candidates knew that boiling point was important but did not realise that this was, in turn, dependant on chain length.

CHEMISTRY

Paper 0620/12

Multiple Choice

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

General comments

Candidates performed well on this paper. **Questions 1**, **3**, **4**, **6**, **8**, **13**, **16**, **19**, **21**, **23**, **25**, **29**, **30**, **36**, **37** and **40** proved particularly straightforward with the vast majority of candidates choosing the correct response. **Question 28** proved to be difficult with only a minority of candidates choosing the correct response.

The following responses were popular **wrong** answers to the questions listed.

Comments on specific questions

Question 2

Response **A.** Candidates did not spot the significance of the word 'quickly'.

Question 7

Response **C**. Candidates chose the alternative which had only one atom of each element, thinki that meant all the electrons were used in bonding.

Question 9

Response **B**. Candidates correctly deduced that a copper compound would be needed but chose the wrong electrode for its deposition.

Question 10

Response **C**. Candidates did not take account of the fact that this is an aqueous solution meaning that sodium would not be liberated.

Question 17

Response **C**. Candidates correctly identified the increase in pH as alkali was added, but did not take account of the fact that the alkali was added in excess.

Question 18

Response **A**. Candidates clearly spotted the barium ion as a correct ion and remembered that a chloride can also sometimes give a precipitate in analysis, not noticing that 'reaction' was asked for rather than 'precipitate'.

Question 24

Response **B**. Candidates were concentrating on the density property of helium rather than its lack of reactivity and incorrectly thought that it was less dense than hydrogen.

Question 28

Response **B**. This response was more popular than the correct answer. Candidates were not aware of how little carbon dioxide is present in the atmosphere. This is a common mistake.

Question 35

Response **B**. Candidates knew that boiling point was important but did not realise that this, in turn, depended on chain length.

CHEMISTRY

Paper 0620/13
Multiple Choice

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

General comments

Candidates performed well on this paper. **Questions 2**, **4**, **5**, **7**, **8**, **10**, **12**, **14**, **15**, **20**, **22**, **28**, **30**, **31**, **33**, **35**, **36** and **37** proved particularly straightforward with the vast majority of candidates choosing the correct response. There were no questions where fewer than 45% of candidates chose the correct response.

The following responses were popular **wrong** answers to the questions listed.

Comments on specific questions

Question 9

Response **B**. Candidates realised that metals are attracted to the cathode but did not take account of the fact that the sodium chloride was aqueous.

Question 18

Response **C**. Candidates correctly identified the increase in pH but did not take account of the excess alkali was added.

Question 23

Response **B**. Candidates concentrated on the density rather than reactivity and incorrectly thought that helium was less dense than hydrogen.

Question 24

Response **B**. Candidates did not know how iron is extracted, or thought that cooking utensils are never made from iron.

CHEMISTRY

Paper 0620/21
Core Theory

Key Messages

- Questions involving equation writing were generally well done.
- More practice is needed in writing the correct formulae for diatomic gases such as O_2 and Cl_2.
- Questions on general chemical properties were generally well done by most candidates. Other candidates need more practice in answering questions relating to qualitative analysis.
- It is important that candidates read the questions carefully in order to understand exactly what is being asked.
- In questions involving free response answers it is important to use the information provided in the bullet points.
- Questions involving atomic structure were generally well done.
- Some candidates need to provide more information, including relevant labels for diagrams.

General comments

Many candidates tackled this paper well, showing a good knowledge of core chemistry. Good answers were seen to many parts of most questions. Nearly all candidates were entered at the appropriate level. A few candidates scored very highly. A few tried to answer some simple calculation questions such as **Question 7(b)** using ideas involving moles. Candidates should be advised that mole calculations are not asked for in this paper. Many candidates misinterpreted what was being asked by some questions. For example, in **Question 2(b)(ii)** some candidates wrote about acidity and alkalinity rather than referring to pH values, whilst in **Question 5(d)(iii)** many candidates described the electronic or atomic structures of argon rather than chemical properties. Many candidates did not use the information provided by the bullet points or the stem of the question where answers requiring free response were required (**Questions 6(a)** and **7(c)**). These are designed to help candidates to structure their answers and write relevant points. Some candidates ignored the instruction to tick two boxes in **Question 3(b)** and only ticked one box. A significant minority of candidates left blank spaces, especially in **Questions 2(c)**, **5(d)(i)**, **7(c)** and **7(e)**. Equations were well constructed by many candidates. Others did not complete symbol equations correctly, especially when diatomic molecules had to be included. The nature of the solid state was not well known in **Question 3(c)(i)**. Many candidates believed that the particles in a solid are moving slightly. Definitions were not always as precise as they might have been, for example, many candidates' answers to the definition of a compound in **Question 1(c)** included the word 'mixture', and the definitions of isotopes in **Question 4(a)** often included differing numbers of protons. Many candidates need more practice at questions involving appropriate separation techniques. For example, in **Question 3(c)(ii)** the candidates should first have considered the state of each of the components to be separated, and then what the most appropriate technique would be. Many candidates missed the essential step of dissolving the salt in water. As in previous sessions, questions involving environmental aspects of chemistry were not done well by many candidates. For example in **Question 7(c)** many candidates did not use the help provided by the bullet points, and did not mention a fuel containing sulfur or the reactions leading to acid rain. A common misconception was that sulfur dissolves in water in the atmosphere to form acid rain. The question on diffusion, **Question 6(a)**, which also involved free response writing, was often not answered in terms of particles, and there were many vague statements. Candidate answers should be structured to include the essential details required. In organic chemistry, many candidates could write the correct molecular formulae of ethane, identify particular hydrocarbons and link the uses of petroleum fractions to their names. The standard of English was reasonably good. Some candidates need to analyse the questions more thoroughly; a considerable number of errors were made by those who did not do so. Few candidates wrote their answers in the t phrases or bullet points. This method is especially useful in questions involving free response an candidates are less likely to contradict themselves if this is done.

Comments on specific questions

Question 1

This question was fairly well answered. Many candidates gave the correct molecular formula of ethene in part **(b)**. The terms in part **(c)** were not always well known, especially the definition of a compound.

(a) Few candidates scored full credit, although many scored the majority of the available credit. In part **(i)** most candidates correctly identified ethene as an unsaturated hydrocarbon. The most common error was to suggest methane. A minority of candidates chose **A** (carbon dioxide) or **E** (ethanol). In part **(ii)** most candidates recognised that carbon dioxide was the combustion product. Others did not read the question carefully enough and suggested a hydrocarbon (**C** or **D**). In part **(iii)** most candidates recognised ethanol as belonging to the alcohol homologous series. A common incorrect answer was **B**. In part **(iv)** many candidates correctly identified methane as being an alkane. The most common errors were to suggest **C** (ethene) or **B** (tetrachloromethane). Many candidates scored credit for parts **(v)** and **(vi)**, the commonest error in both being to suggest methane.

(b) The majority of candidates gave the correct molecular formula for ethane. The main errors were to suggest C_2H_6 or CH_4.

(c) A minority of candidates correctly defined the term 'compound'. The main error was to suggest that compounds are mixtures of elements. Many candidates gave vague answers such as 'a pure substance made of two atoms' or omitted the idea of the atoms bonding or joining together. Many realised that 'inert' means 'does not react' or similar. Others did not go far enough and suggested that it means a 'low reactivity' or 'is not very reactive'. A minority suggested, incorrectly, that inert means 'it lights up'. Nearly all candidates gave a suitable definition of a catalyst. A few misinterpreted the question and wrote the names of elements or compounds which they thought might be catalysts.

Question 2

Few candidates scored well in this question, parts **(b)(ii)** and **(c)** proving to be the most demanding. A significant proportion of candidates gave no response to part **(c)**, and few knew all the details of the test for copper ions. The dot and cross diagram for hydrogen chloride in part **(a)** caused particular problems for many candidates.

(a) Fewer than half the candidates were able to draw the correct dot and cross diagram for hydrogen chloride. Many drew the structure as a single circle, i.e. without the hydrogen atom and put HCl in the centre of this circle. Others put too many electrons in the outer electron shell. A significant number of candidates showed the structure as either ionic or as a semi-ionic form by putting + and – charges, or showed the atoms as separate entities.

(b) (i) Many candidates were able to identify the burette and flask correctly. The commonest errors were to suggest pipette instead of burette, and beaker instead of flask. Other common errors for the burette were 'tube', 'graduated syringe' and 'dropper'.

(ii) Very few candidates were awarded full credit. The commonest error was to omit pH values at the start or at the end of the titration. Most candidates scored credit for the idea that the pH decreased. Many did not mention pH at all, and just mentioned acidity and alkalinity. Others did not read the stem of the question carefully enough and only stated the pH level changing to neutral rather than stating what happens to the pH when the acid is in excess. There were many vague statements about neutralisation. A significant minority suggested that the pH increases when the acid is added.

(iii) A significant majority of candidates were able to correctly name ammonium chloride b able to give the correct formula of ammonia. Ammonium chloride was often incorrectly 'ammonia chloride' or 'ammonia hydrochloric acid'. Many nitrogen compounds such as hydrochloride' were also seen. Common errors in the formula for ammonia were NH_4 and NH

(c) Only a minority of candidates scored well here. There were many confused answers implying tha the precipitates were soluble without writing the word 'excess'. Many gave answers that suggested that they were reacting copper metal rather than copper ions. Other common errors included: the omission of the word 'precipitate'; using the word 'cloudy' in place of the word 'precipitate'; not mentioning what happens when excess ammonia is used; suggesting that the precipitate is only formed when excess ammonia is used.

Question 3

This was one of the best answered questions on the paper. Parts **(b)** and **(d)** were particularly well done. The reason why iron will not react with zinc oxide in part **(a)(ii)** was not always well explained and many vague statements were seen.

(a) (i) Many candidates thought that lead was the most reactive of the metals and reversed the series completely, so only gaining minimal credit. Others made additional errors, so did not score any credit. Common errors included writing down the name of the oxides of the metals, writing only three metals in the boxes, and giving the name of a metal which was not on the list.

(ii) Only a minority of candidates were able to explain why iron does not react with zinc oxide. Common errors included answers about heating, vague statements such as 'iron cannot replace the zinc in the oxide' and answers giving the correct reason but suggesting that iron does react with zinc oxide.

(b) This was well answered by the majority of the candidates. The commonest error was to suggest that all metals have a high density. A significant number of candidates only ticked one box instead of two as stated in the stem of the question.

(c) (i) Many candidates scored full credit. A wide variety of suitable answers were seen, especially with regard to the arrangement of the particles. A number of candidates did not score credit for their descriptions of the 'arrangement' because they wrote vague statements such as 'the arrangement is neat' or gave irrelevant statements such as 'from solid to liquid'. Fewer candidates successfully described the 'movement', common errors being 'bump into each other', 'move in a specific area' or 'barely move from place to place'. The last was not accepted because it implies that there is some translational movement in a solid.

(ii) Few candidates scored full credit. The majority scored minimal credit, generally for the suggestion that the mixture should be filtered. Many did not mention that water had to be added to dissolve the salt. A significant number of candidates implied that the solid mixture of salt and sand was filtered. Those who wrote about sodium chloride 'going through the filter paper' often omitted to state that the sodium chloride was in solution. A minority of candidates suggested, incorrectly, that fractional distillation should be used.

(d) Most candidates had a good grasp of the terms used in distillation and many scored all or most of the available credit. Errors were most commonly observed in the second gap (where 'heavy' or 'higher' were often given instead of 'lower') and in the fourth gap (where 'flask' or 'heavy' were often chosen instead of 'condenser').

Question 4

Many candidates scored well on this question especially in part **(b)**, where they were asked to draw the structure of a lithium atom, although a significant minority did not answer this question. The balancing of the equation in part **(c)** was generally well done, with many candidates scoring full credit. Some candidates omitted the labelling of the anode and electrolyte in part **(d)(i)**. The explanation of why aqueous lithium chloride conducts electricity was not well known.

(a) A minority of candidates gave a convincing explanation of the term 'isotope'. The main errors were to suggest different numbers of protons or atomic number, to write about different charges on the neutrons, writing about elements or molecules rather than atoms or confusing isomers.

(b) Many candidates drew good labelled diagrams of a lithium atom. Many drew an appropriate place of the labelling. The best showed the protons and neutrons in the nucleus as well as correct number of these particles. Most candidates showed the correct electron configuration an gained the majority of the available credit for this.

(c) Many candidates were able to balance the equation for the reaction of lithium with oxygen. The main error was to write oxygen as O instead of O_2. A significant minority wrote the oxide ion. The major error was in the balancing of lithium, ratios of 2Li to $2Li_2O$ or 4Li to $4Li_2O$ being frequently seen.

(d) (i) Many candidates successfully identified the anode as the positive electrode. Fewer identified the electrolyte. The commonest errors were to label the wires as the anode or to label the anode as the electrolyte.

(ii) About half the candidates realised that an aqueous solution involved water. Many definitions were rather vague. The commonest error was to refer to liquid instead of water. Some referred to water as being a solute. Other common errors included reference to mixtures and reference to acids or alkalis.

(iii) Few candidates referred to ions. Even fewer referred to the movement of these particles. Common errors included ‘in the liquid state’, reference to aqueous lithium chloride being a metal or a salt, or ‘water is a good conductor’.

Question 5

Many candidates scored well on this question, especially in parts **(a)** and **(d)(ii)**. A significant number of candidates did not attempt parts **(d)(i)** and **(d)(iii)**. The question on the comparison of fuels in part **(b)** was reasonable well done, although many candidates gave vague or incorrect answers as to why the water should be kept stirred.

(a) Many candidates could link the fuels to their correct use. The commonest errors were to suggest that hydrogen is present in natural gas, that methane is used as a fuel for ships, or that kerosene has a relative molecular mass of 2.

(b) (i) The majority of candidates were able to suggest a correct factor that should be kept the same in each experiment. The commonest correct answers were to refer to the same copper can or the same amount of water. Common incorrect answers included ‘same amount of heat supplied’, which was too vague, time of burning, temperature of the water at the start, and vague statements about the spirit burner or fuel.

(ii) Only a minority of candidates gave a suitable reason for keeping the water stirred. The best answers referred to keeping all the water at the same temperature. The commonest errors were unqualified reference to particle collisions, ‘to stop the reaction going too fast’ or ‘making the reaction more effective’. A significant minority of candidates did not seem to realise that the reaction was the burning of the fuel and not the heating of the water.

(iii) The majority of candidates realised that the petroleum spirit gave the most energy on burning. Fewer calculated the temperature differences and gave the incorrect answer referring to the highest temperature reached. The best candidates showed their calculations clearly on the table. A significant minority chose propanol as the (incorrect) fuel because the final temperature of the water was the highest. Others chose paraffin (incorrect) because it had the lowest temperature rise. Candidates should be advised to choose their wording carefully. Answers such as ‘it starts at 24 degrees and finishes at 42 degrees’ do not go far enough to gain credit.

(c) About half the candidates correctly identified nitrogen and oxygen in their correct proportions as the major gases in the air. The commonest errors were to suggest that oxygen is the major and nitrogen the minor part of the air, that hydrogen is present in the air, or that carbon dioxide forms about 20% of the air.

(d) (i) A small proportion of the candidates stated a correct use for argon. The commo t answers were balloons, fuel or to 'make fire', or for breathing. Many wrote statements not related to uses. For example: 'it's in the air'. Others gave statements which were to for example, 'used in industry'.

(ii) Most candidates correctly identified argon as belonging to period 3 of the Periodic Table. The commonest errors were '0' (confusing Groups with periods) or giving a Group name such as halogens or noble gases.

(iii) A minority of the candidates realised that argon is inert or unreactive. Many candidates suggested that it does react, by giving answers such as 'it is less reactive' or 'not very reactive'. A considerable proportion of the candidates mentioned electronic structure or proton number instead of writing about chemical properties.

Question 6

The extended writing in part **(a)** of this question did not provide much credit for most candidates. Many vague answers were seen without reference to the particle theory. A significant number of candidates did not answer this part of the question. The equation in part **(b)** was often balanced correctly although the formula for a chlorine molecule was known only by the highest scoring candidates.

(a) Most candidates scored minimal credit. Only a few scored higher. The majority of the candidates did not mention particles and were awarded the credit for the idea of dissolving or diffusion. Many thought that the ions were reacting with water. Only the better candidates wrote about movement of ions or particles. Many candidates disadvantaged themselves by writing incorrect statements about the precipitation, for example, 'iodine becomes yellow'. Many repeated the information in the question by stating that 'a yellow precipitate is formed'.

(b) Many candidates correctly balanced the equation. Few scored full credit because $2Cl$ was written instead of Cl_2. Others did not gain credit because they did not balance the (incorrect) Cl. A significant minority of candidates gave the symbol for iodine or iodide instead of Cl_2.

Question 7

This question was the least well answered on the paper. The calculation in part **(b)** provided only a minority of candidates with credit as did the extended writing about acid rain in part **(c)**. Many candidates left parts **(b)**, **(c)** and **(e)** unanswered. The best candidates knew the test for the sulfate ion. Others gave tests for cations or water.

(a) A high proportion of the candidates calculated the number of atoms in three molecules of sulfur correctly. The commonest incorrect answers were multiples or fractions of 24, e.g. 48, 420, 8.

(b) About a third of the candidates calculated the relative molecular mass of S8 correctly. Common incorrect answers were 32 (the atomic mass), 128 (multiplying the atomic number by 8) or 96. A few candidates attempted mole calculations even though the mole is not examined in this paper.

(c) The best candidates scored the majority of the available credit, but few scored full credit. Most candidates scored some credit. Many answers were unstructured and many candidates did not appear to use the bulleted phrases to help them structure their answers. The commonest errors were to omit the name of a fuel containing sulfur, or to give the name of a type of hydrocarbon rather than a fuel, such as methane or octane, to suggest that sulfur dissolves in water in the atmosphere, or to make no mention of sulfur oxides dissolving in water. Very few candidates mentioned sulfur dioxide being oxidised further in the atmosphere.

(d) A minority of candidates realised that the other two elements present in (NPK) fertilisers were nitrogen and phosphorus. Some wrote the names of ions, such as nitrate, instead of elements. A wide variety of metallic elements were seen, the commonest of which were magnesium and calcium. The elements oxygen and carbon were also frequently seen as incorrect answers, as was the compound carbon dioxide.

(e) The best candidates explained the test for sulfate ions in detail. Many realised precipitate was formed but gave the test reagent as sodium hydroxide. Others precipitates of various colours other than white. Other common errors included the use paper, the use of copper sulfate, or white precipitate with silver nitrate.

CHEMISTRY

Paper 0620/22
Core Theory

Key Messages

- Questions involving equation writing were generally well done.
- More practice is needed in writing the correct formulae for diatomic gases such as O_2 and Cl_2.
- Questions on general chemical properties were generally well done by most candidates. Other candidates need more practice in answering questions relating to qualitative analysis.
- It is important that candidates use the information, including diagrams, in the stem of the question to help them in their answers.
- In questions involving free response answers about changes of state it is important that specific states, i.e. solid or liquid are referred to.
- Questions involving structure and bonding were generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core chemistry. Good answers were seen to many parts of most questions. Nearly all candidates were entered at the appropriate level. A few candidates scored very highly. Very few candidates misinterpreted the questions. The only case where this was done was to mistake the term 'petroleum fraction' to mean fractional distillation. Many candidates did not use the diagrammatic information provided in the stem of **Question 7(a)** where a free response answer was required. This was designed to help candidates structure their answer and write relevant points. A significant minority of candidates left blank spaces, especially in **Questions 2(d)(i)**, **5(c)** and **6(b)(i)**. Symbol and word equations were generally well constructed by many candidates. Others did not complete symbol equations correctly, because of incorrect species written as products, e.g. hydrogen instead of water in **Question 3(c)**. The nature of the solid and liquid states were not well known (**Question 7(a)(i)**). Many candidates believed that the particles in a solid are moving slightly and that in liquids they are some distance apart and moving rapidly. Definitions were not always as precise as they might be. For example, the candidate answers to the definition of an element in **Question 1(d)** often included ideas about the same molecules or general ideas about atoms and the answers to the meaning of petroleum fractions in **Question 4(a)** generally included ideas about the process of fractional distillation. Many candidates need more practice at questions involving appropriate separation techniques. For example in **Question 3(d)(ii)** the candidates should have considered the difference in the size of the particles involved in filtration. As in previous sessions, questions involving qualitative analysis were not well known especially when excess sodium hydroxide is used. Many candidates also need revision on the methodology of salt formation using an acid and alkali as well as the selection of a suitable acid to make a particular salt. Analysis of data from tables and graphs was generally well interpreted. Many candidates showed a good understanding of the structure and bonding of substances such as potassium iodide and diamond. Fewer could link properties to the type of structure and bonding in a compound. Most candidates showed a good understanding of rates of reaction and basic organic chemistry, although the definition of a hydrocarbon was not always accurate enough. Improvements need to be made in the way candidate answers are structured to include the essential details required. In organic chemistry, many candidates could write the correct molecular formulae of ethane, identify particular hydrocarbons and link the uses of petroleum fractions to their names. The standard of English was reasonably good. A minority of candidates need to analyse the questions more thoroughly since a number of errors were made by not doing so. Few candidates wrote their answers in the form of short phrases or bullet points. This method is especially useful in questions involving free response answers, and candidates are less likely to contradict themselves if this is done.

Comments on specific questions

Question 1

Most candidates scored well in this question, part **(a)** being particularly high-scoring. In part **(c)** most candidates could identify the correct structure of diamond. The definition of an element was not well known, with many candidates writing vague and often contradictory statements.

(a) The majority of the candidates scored most of the available credit for this question. The answers to parts **(i)** and **(ii)** were almost invariably correct. The most common error in part **(ii)** was to suggest that **B** (diamond) was used to fill weather balloons. Most candidates identified chlorine as a diatomic gas and again the most common error was to suggest carbon (diamond). A few candidates suggested ethanol. In part **(iv)** most candidates recognised the metal (copper) as being an electrical conductor. A minority suggested diamond, possibly muddling the structure with that of graphite. A majority of the candidates also recognised that copper is a transition element. Yet again, the main error was to suggest **B** (diamond).

(b) Only about one third of the candidates recognised that chlorine and phosphorus are simple molecules. The main error was to suggest **A** and **E** (copper and helium). **B** (diamond) was also often incorrectly suggested.

(c) Most candidates recognised that element **B** (diamond) was a giant structure with covalent bonding. The commonest errors were to suggest that diamond is a simple molecule or a metal. Few candidates suggested that it was ionic.

(d) Some candidates gave good definitions of the term 'element'. Others contradicted themselves, e.g. stating 'compounds with one type of atom', or were not specific enough, giving answers such as 'metals and non-metals in the periodic table', 'molecules with a specific mass' and 'simple substances'. Few candidates mentioned that elements could not be broken down further by chemical means. Some candidates mentioned 'same molecules' but this could not be credited.

Question 2

This question proved to be the most demanding on the paper. The preparation question in part **(d)** was not well answered except by the best candidates, and many did not attempt it. The test for ammonia was reasonably well known, as was the symbol equation for the reaction between ammonia and hydrochloric acid. Many candidates drew good dot and cross diagrams for hydrogen chloride, although a significant minority did not appear to know the formula of this gas, or drew an ionic structure.

(a) About half the candidates gave the correct test for ammonia. Some muddled the test with that for a nitrate and suggested that aluminium and an alkaline solution should be used as the test reagent. A significant minority did not mention the colour of the litmus paper, or suggested that blue litmus turns red. The other error often seen, was the suggestion that sodium hydroxide was the test reagent.

(b) Many candidates suggested the correct pH for an aqueous solution of ammonia (pH 9) from the list given. No other incorrect value from the list could be singled out as a common error.

(c) (i) Fewer than half the candidates completed the symbol equation for the formation of ammonium chloride correctly. Common errors in the formula for ammonium chloride were NH_3Cl, $NHCl$ and NCl. A significant minority gave mixtures of products such as $NCl + H_2$.

(ii) About half the candidates drew the electronic structure of hydrogen chloride correctly. Many implied an ionic structure by drawing the hydrogen separately from the chloride, and some showed ionic charges. Others drew an arrow from the hydrogen to the chloride which also implies a complete transfer of an electron and hence implied an ionic structure. Other errors commonly seen were eight electrons around the hydrogen and a structure containing three hydrogen atoms and one chlorine atom.

(d) (i) The best candidates realised that ammonia had to be titrated with sulfuric acid and th[illegible] had to be used. Many candidates suggested titrating with sodium sulfate or coppe[illegible] ignored the titration altogether by starting with ammonium sulfate. Others added hydrochl[illegible] rather than sulfuric acid. These two errors led to a reduction in the maximum credit which co[illegible] obtained. A minority of the candidates added an indicator and even fewer mentioned titrating ag[illegible] in the absence of indicator. Others wrote vague comments about indicators, implying that they were added after the titration or that the ammonia was titrated with the indicator.

(ii) A minority of the candidates realised that they had to evaporate the solution to the crystallisation point, or heat the solution a little then allow it to cool. The commonest errors were heating to evaporate all the water, evaporation without any further qualification, the word 'crystallisation' without any further qualification and filtration or distillation.

Question 3

This question was reasonably well answered by most candidates, most scoring over half of the available credit. The extraction of data from the table and prediction of the state and melting point in part **(a)** was generally well done and the symbol equation in part **(c)** was often balanced correctly. There were many vague answers to part **(d)(ii)** where many candidates did not appreciate that the sand was the filtering medium.

(a) A majority of the candidates answered this correctly. Part **(i)** was particularly well answered and only a few candidates gave the colours of each of the halogens, gave one colour, or thought that they got lighter in colour down the Group. Most candidates realised that fluorine would be a gas at room temperature, the commonest error being to suggest that it would be a liquid. Fewer candidates gave an acceptable value for the melting point of chlorine. It was commoner to give incorrect values of less than –180 °C than values greater than –20 °C. A significant minority ignored the minus sign.

(b) (i) About half the candidates were able to put the halogens in the correct order of reactivity. The main errors were a complete reversal of the order, reversal of chlorine and bromine and the order iodine > bromine > chlorine > astatine.

(ii) Fewer than a quarter of the candidates were able to give a correct reason why bromine will not react with sodium chloride. Some referred to reactivity in rather a vague manner without mentioning one or other of the elements, e.g. 'going down the series the reactivity decreases' or 'bromine is lower in the Group than chlorine'. Some made a comparison, incorrectly, with sodium or sodium chloride. Many referred, incorrectly, to differences in state or electrical conductivity.

(c) The symbol equation was generally balanced correctly. Those who wrote the correct formula for water as a product generally obtained full credit. The main error was to write hydrogen as a product instead of water.

(d) (i) A majority of the candidates gave a good explanation as to why chlorine is used in water purification. The commonest incorrect answers referred to reactivity, removal of impurities or rather vague statements such as 'to make water clean'.

(ii) The best candidates realised that the particles of sand acted as the filter and gave answers either relating to differences in particle sizes or making it clear that the water drains right through and the sand traps the insoluble particles. A large minority of candidates gave answers that suggested that either the sand was being filtered from the water or that there was a filter paper at the top or bottom of the filter. Many candidates did not score the credit for the water draining through because they wrote vague statements about the water coming out or implied that the water flowed over the top of the filter.

Question 4

This question was reasonably well answered by many candidates. Parts **(b)**, **(d)(ii)** and **(e)(** particularly well answered. A few candidates were able to give good explanations of a petroleum frac part **(a)**. Others referred to the process of distillation rather than the nature of the products. The definitio the term ‘hydrocarbon’ was not always exact enough and lacked the essential idea that they contain n elements other than carbon and hydrogen.

(a) A few candidates referred to groups of hydrocarbons or named two or more fractions. The majority gave answers which referred to the process of fractional distillation, instead of referring to the products of distillation. A few candidates knew that each fraction has a specific range of boiling points. Others only referred to boiling points in the context of fractional distillation and so did not gain the credit.

(b) (i) Most candidates named two fractions for which demand is greater than supply. The commonest error was to suggest ‘lubricating oil and bitumen’.

(ii) About half the candidates identified suitable uses for the two fractions. Common errors for the refinery gas fraction were based on rather vague statements such as ‘for ships’, ‘for gas burners’ or ‘for separations’. Common errors for the bitumen fraction were ‘for lubrication’ or ‘for fuels’.

(c) Many candidates realised that a high temperature is necessary for cracking. A minority were not specific enough and wrote ‘temperature’, ‘the right temperature’ or ‘optimum temperature’. The requirement of a catalyst was less well known than the requirement for a high temperature. Many candidates suggested high pressure.

(d) (i) About a third of the candidates gave a good definition of the term ‘hydrocarbon’. The commonest error was to omit the essential idea that no other elements, apart from carbon and hydrogen are present. Some candidates omitted to mention hydrogen and a significant number suggested, incorrectly, that carbon and oxygen are present.

(ii) A majority of the candidates successfully completed the equation for cracking. The main errors were in not counting the atoms and giving only the number of carbon atoms or hydrogen atoms correct but not both. The commonest errors were C_4H_{10} and C_3H_8. A significant minority of candidates appeared to add or multiply the atoms so that incorrect species such as $C_{16}H_{20}$ were suggested.

(e) (i) Over half the candidates drew the correct displayed formula for ethene. The main error was to put a single bond between the two carbon atoms. The number of hydrogen atoms was almost invariably correct.

(ii) A majority of the candidates gained full or nearly full credit for this question. The commonest errors were to write ‘monomers’ instead of ‘polymers’ and vice versa, or to write ‘atoms’ instead of ‘monomers’ or ‘addition’.

Question 5

Some candidates scored well on this question, but most scored fewer than half the available credit. The differences in the physical properties between aluminium and iron were not well known in part **(a)** and less than a third of the candidates described the test for aluminium ions in full detail in part **(c)**. A significant number of candidates did not respond to part **(c)**.

(a) Many candidates muddled the properties of transition elements with those of aluminium. This led to incorrect statements such as ‘iron is a good conductor and aluminium is not’ or ‘aluminium is dense and iron is strong’. Some candidates did not compare like with like. Others gave uses instead of properties. Other common errors were to suggest that one of the metals is shiny and the other is not, to suggest that one conducts and the other does not, or to repeat the information in the stem of the question about boiling points.

(b) A majority of the candidates gave a suitable use for aluminium. Its uses in building aircraft, for saucepans and as an electrical conductor were well known. Common errors ranged from vague statements such as ‘in utensils’ or ‘in wires’ to incorrect statements such as ‘for galvanising’.

(c) The best candidates wrote straightforward descriptions of the test based on the info syllabus. Others knew that sodium hydroxide is used but gave confused answers, 'insoluble solutions' or 'soluble precipitates' without stating whether or not the sodium h was in excess. A considerable minority thought that the precipitate did not dissolve in e sodium hydroxide.

Question 6

This question was the best answered on the paper. Most could name a rock containing calcium carbonate in **(a)**, and gained full credit for the completion question about combustion in **(b)(ii)**. The effect of different factors on speed (rate) of reaction was well known in **(d)(ii)**. The symbol equation for the reaction of carbon with oxygen to form carbon dioxide was reasonably well known, although a significant number of candidates did not respond to this question.

(a) (i) The majority of candidates recognised a rock made of calcium carbonate. Limestone or marble were the commonest correct answers. Chalk was seen less often. The commonest incorrect answer was h(a)ematite. Lime, salt or named salts were other incorrect answers occasionally seen.

(ii) About half the candidates realised that the gas/carbon dioxide is released from the kiln, leaving only lime. Some candidates did not refer back to the equation and so gave incorrect answers such as 'reacts with coke so making lime'. Others did not refer to the gas and gave incorrect answers such as 'the calcium carbonate has already reacted' or 'the solid evaporates'.

(b) (i) About half the candidates successfully wrote the symbol equation for the complete combustion of carbon. Many wrote oxygen as 2O instead of O_2 or left the oxygen as O. The correct product, CO_2, was frequently seen, but a significant minority wrote CO, CO_2 + H_2O or may still have been thinking of the previous question when they wrote CaO (often with Ca on the left).

(ii) Nearly all candidates scored at least half of the available credit for this question and many scored all full credit. The commonest errors were writing 'air' in the first space instead of 'limited', 'water' in the second space instead of 'air', and 'carbon dioxide' in the third space instead of 'carbon monoxide'.

(c) Most candidates scored at least some credit for the equation and many scored full credit. Common errors were 'calcium hydrochloride' instead of 'calcium chloride' and 'hydrogen' instead of 'water'.

(d) (i) Some candidates gave simple and succinct answers by referring to timing the change in mass. Others wrote a lot about the experiment but did not succeed in gaining any credit because they focused on the hydrochloric acid, the cotton wool or just mentioned 'use the top pan balance' or 'use a stopwatch'. Credit was given if candidates mentioned taking the time before and after the reaction had finished, but not just for using a stopwatch. A significant minority of candidates suggested 'record the speed with a stopwatch'. This was not considered sufficient enough to gain credit. The credit for time was given less often than that for measuring the mass.

(ii) The effect of different factors on speed (rate) of reaction was well known in **(d)(ii)**. Most candidates used words such as 'increases' or 'decreases' (speed). A few used words such as 'takes a longer time'. This was not accepted because it refers to time rather than speed. The effect of using larger pieces of calcium was the one which was least well known. Only a few candidates suggested that there was no effect when one of the factors was altered.

Question 7

Some candidates scored well on most parts of this question. Others did not score well especially where extended prose and ordering of information was required, and in **(c)** where the relationship be solubility, electrical conductivity and structure was tested. The concept of relative molecular mass o diatomic molecule was not understood by many candidates. Many could identify the type of bonding i potassium iodide and predict the products of electrolysis of the molten compound.

(a) (i) Few candidates made it clear whether they were writing about solid or liquid iodine. Many referred to iodine vapour, even though the data provided did not include data about the gaseous form. Many just wrote about the particles moving more when the iodine was heated without reference to the state. Many candidates disadvantaged themselves by writing about fast moving particles. Candidates should be advised to answer this type of question as a series of bullet points or short phrases, e.g.

- Before heating, the particles are close together and only vibrating.
- When heated, the particles gain energy and vibrate faster.
- When liquid, the particles slide over each other but are still close together.

This format easily gains credit.

(ii) Few candidates realised that they had to multiply the atomic mass of iodine by 2, even though a diagram showing that iodine is diatomic was given in the stem of the question. Common incorrect answers other than 127 were 180 (adding the atomic mass to the atomic number) and 106 (multiplying the atomic number by 2).

(b) Many candidates recognised that potassium iodide has an ionic structure. The commonest errors were to suggest covalent or metallic. Most candidates gave the correct formula for potassium iodide. The commonest errors were K^+I, KI^-, KI_2 and PI.

(c) Although many candidates realised that potassium iodide is ionic by reference to their answer in **(b)**, most did not use this information to answer this question. Many suggested that the salt was insoluble and conducted electricity when solid. The best answers made it clear that it only conducted when molten or in aqueous solution. Many did not use the information from the diagram that iodine is a molecule to give the correct answers about the (in)solubility and (lack of) conductivity of iodine. Credit was most often awarded for the insolubility of iodine. A considerable number of candidates left one or two of the squares in the answer grid blank.

(d) Many candidates scored full credit for this question. Common errors were reversing iodine and potassium, suggesting that hydrogen was given off at one or other of the electrodes, writing iodide as an anode product instead of iodine, or suggesting that chlorine rather than iodine was given off at the anode.

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Paper 0620/23
Core Theory

Key Messages

- Questions involving equation writing were generally well done.
- Questions on general chemical properties were generally well done by most candidates. Other candidates need more practice in answering questions relating to organic chemistry.
- It is important that candidates read the question carefully in order to understand exactly what is being asked.
- It is important to remember the tests for ions in appropriate detail for the theory papers as well as for the practical paper.
- More practice is needed at answering questions requiring extended prose.
- Interpretation of data from graphical information and the drawing of graphs were both generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core chemistry. Good answers were seen to most parts of every question. Nearly all candidates were entered at the appropriate level. Many candidates misinterpreted what was being asked by some questions. For example, in **Question 1(b)(ii)** most candidates drew the dot and cross diagram for a chlorine atom rather than a chlorine molecule, whilst in **Question 3(c)** many candidates did not give a reason for their answer as to why indigo is an unsaturated compound. Similarly, in **Question 4(b)(iv)**, many ignored the instruction to give a reason for their answer. Some of the questions were left unanswered by a small proportion of the candidates. This was especially apparent in **Questions 3(a)**, **4(a)(i)**, **7(e)** and **8(c)(ii)**. The extraction of information from graphs was generally good, as was graph plotting. Some candidates joined the points to the (0, 40 °C) mark for which there was no data. The extrapolation of the graph was also generally successfully done. Many candidates could also extract relevant information from a diagram in **Question 8(a)**. Equations were well constructed by many candidates. Others had difficulty in writing word equations correctly and in balancing symbol equations. Hardly any candidates wrote symbol equations where word equations were asked for or vice versa. The balancing of equations by placing numbers in the appropriate spaces was generally well done. A considerable minority of candidates did not realise that chlorine is diatomic. Definitions were not always as precise as they might be. For example, the candidates' answers to the definition of an enzyme in **Question 5(b)(ii)** often omitted to state that enzymes are catalysts. Explanations of the term 'endothermic' were generally well written. Many candidates need to improve their knowledge of environmental chemistry. For example, in **Question 4(a)(ii)** and **4(a)(iii)** many gave confused answers whilst in **Question 6(a)** many candidates muddled the origin of lead in the atmosphere with the origins of other pollutant compounds. Some candidates knew the tests for the chloride ion and iron(II) ions. Others did not write enough detail or chose additional incorrect reagents. For example, in **Question 7(e)**, despite being told in the stem of the question that silver nitrate is used to test for chloride ions, some candidates mentioned litmus. Many candidates had a good grasp of chromatography and analysis of the result. In organic chemistry, many candidates could write the correct displayed formulae of methane but fewer could recall the conditions needed to make ethanol from ethene or state that steam is necessary in this reaction. Candidates need more practice in answering extended questions such as a descriptions of the main points of iron extraction. Few candidates knew the main ideas about the reduction of iron oxide with carbon or carbon monoxide. Few candidates tackled this main free response question, **8(b)**, by writing their answers in the form of short phrases or bullet points or by giving relevant equations as requested. Candidates are less likely to contradict themselves if this is done.

Comments on specific questions

Question 1

Most candidates scored at least half marks in part **(a)**. In part **(b)(i)** most candidates cold balance equation although fewer wrote the formula for the chlorine molecules correctly. In part **(b)(ii)** only the bes candidates drew a dot and cross diagram of a chlorine molecule. Most drew a chlorine atom.

(a) In **(i)** nearly all candidates gave the correct answer. The commonest error was to suggest helium. A few candidates suggested nitrogen or oxygen. Nearly all candidates answered **(ii)** correctly. A wide variety of incorrect answers were seen. The commonest incorrect answers seen in **(iii)** were bromine or sulfur. Most candidates realised in **(iv)** that nitrogen forms about 70% of the air. Oxygen was the commonest incorrect answer. A few candidates suggested hydrogen or helium. Part **(v)** was generally answered correctly, the commonest error being 'hydrogen'. Part **(vi)** was the least well done, with chlorine as a common incorrect answer.

(b) (i) Most of the candidates were able to balance the equation. A large proportion wrote $2Cl$ instead of Cl_2.

(ii) The best candidates drew good, neat dot and cross diagrams to show the structure of a chlorine molecule. Most drew the structure of a chlorine atom. It is important that candidates learn to read the question carefully in order to distinguish terms such as atom and molecule.

Question 2

This was one of the best answered questions in the paper. Many candidates showed a good grasp of formula writing, understood the term 'solubility' and could correctly deduce the likely pH of ethanoic acid. Others did not respond to part **(a)(ii)** and/or wrote the simplest formula for sodium carbonate incorrectly in part **(f)**.

(a) (i) Over half the candidates could identify the carboxylic acid group in ethanoic acid. The commonest error was to put a ring around the C=O group only. Other errors were to ring OH or COH atoms.

(ii) This was the least well done part of **Question 2**. Many candidates drew a simplified structural formula or an empirical formula. Many candidates did not use the information given in the structure in the stem of the question, and gave structures such as CH_2COOH or multiples of $C_2H_4O_2$. Others divided ethanoic acid up into several parts, e.g. $CHCO_2 + H_2$ or wrote a general formula.

(b) Fewer than half the candidates realised that the reaction between sodium hydroxide and ethanoic acid was an example of neutralisation. A wide range of incorrect answers were seen, redox, addition or exothermic being the commonest.

(c) The great majority of the candidates gave good definitions of the tem 'soluble'. A minority suggested, incorrectly, 'reacts with water' or 'solid in a liquid'.

(d) Nearly all candidates realised that pH 3 is acidic. The main errors were to suggest pH 7 or pH 9.

(e) Most candidates were able to complete the general equation for the reaction of an acid with a carbonate. Hardly any gave specific names in place of salt. The commonest errors were hydrogen instead of water, and carbon acid or acid carbonate instead of carbon dioxide.

(f) Many candidates were able to deduce the formula of sodium carbonate from the diagram provided. The main errors were $NaCO_3$, multiples, e.g. Na_4CO_6, incorrect ionic species, e.g. $Na_2^{+}CO_3^{2-}$.

Question 3

Many candidates scored highly on this question especially in **(b)**. Some left part **(a)** unanswered. made simple errors in placement of the solvent. In part **(c)**, many candidates gave the answer 'unsatu but did not follow the instruction to give a reason for the answer.

(a) About half the candidates drew the solvent line in the correct position. Few drew the solvent above the spot but many did not gain credit because they drew the solvent level with the spot. Others drew the solvent below the level of the paper.

(b) (i) Most candidates recognised the separation method as being chromatography. Those who did not know generally did not answer.

(ii) Many candidates scored full credit for this question by drawing accurate diagrams of the separated spots. The commonest error was to not show the solvent front. Others drew the solvent front below the spots. A minority of candidates drew the spots separated horizontally as well as vertically. A few candidates only drew three spots and did not make it clear that any fourth spot remained on the base line if the component was insoluble.

(c) Many candidates did not score credit because they did not read the stem of the question properly, which asked for a reason why indigo is unsaturated. Many simply wrote the word 'unsaturated' (or saturated) without any further explanation. A considerable minority gave the correct reason but suggested that the compound was saturated.

Question 4

Parts **(a)(i)**, **(a)(iv)** and **(b)(i)** were well answered by the majority of candidates, although a considerable number did not respond to part **(a)(i)**. Many candidates gave confused or vague answers to the question about greenhouse gases, **(a)(ii)**. Reversible reactions were understood by many of the candidates. Part **(b)(iv)**, which required candidates to give a reason why carbon dioxide is an acidic oxide, was not well answered. Many only wrote the word 'acidic' (or basic) without any further explanation.

(a) (i) Many candidates correctly drew the structure of methane. The main errors were omitting a hydrogen atom or drawing the structure of ethene with a single bond instead of a double bond.

(ii) The meaning of term 'greenhouse gas' was explained well by a minority of candidates. Most wrote vague statements referring to pollutant gases, poisonous gases or the effect on the ozone layer.

(iii) About half the candidates gave a suitable source of methane. Others gave vague answers such as 'pollutant gases', 'waste gases' or 'car engines' or incorrect answers such as 'in carbon dioxide' or 'in hydrogen'.

(iv) Many candidates completed the calculation correctly. A few rounded up in the middle of the calculation and therefore did not obtain the correct answer.

(b) (i) Most candidates correctly referred to the double-headed arrow. Others did not gain credit because they wrote about the meaning of equilibrium, often incorrectly, e.g. 'the same amount of atoms on each side of the equation' or 'both sides have the same amount of elements'. A small minority gave answers unrelated to the question such as 'physical change'.

(ii) Fewer than half the candidates were able to describe the meaning of 'reversible' in terms of the reaction going backwards or forwards. Many gave answers which paraphrased the question, such as 'it can be reversed'.

(iii) About half the candidates stated a suitable source of carbon monoxide in the atmosphere. Others wrote answers that were not quite full enough to obtain credit. For example: 'incomplete combustion' (missing out fuels or a named fuel) or 'from cars'.

(iv) A few candidates knew that carbon dioxide is an acidic oxide and gave a reason. The majority of candidates wrote 'basic oxide', or did not give a reason. A significant number gave the self-evident reason that 'carbon dioxide is acidic' or wrote about the gas dissolving in water to form an acid.

Question 5

The better candidates performed very well on this question. Most showed good ability in graphical w
many were able to interpret the information from the table in part **(c)(i)**. Fewer candidates were able t
convincing answers to the organic chemistry questions in **(a)** and **(b)**. A significant number of candidates
not respond to parts **(a)(ii)** and **(b)(i)**.

(a) (i) A minority of the candidates were able to state the name of the substance that needs to be added to ethene to make ethanol. The commonest incorrect answers were alcohol, catalytic cracking, ethanoic acid and hydrogen.

(ii) Few candidates gave two correct conditions for the hydration of ethene. The majority did not gain credit because they wrote ‘temperature’ or ‘optimum temperature’ unqualified, rather than ‘high temperature’. Many did not know the difference between conditions and reagents. Water, for example, is not a condition.

(b) (i) About half the candidates gained credit for the word equation for fermentation. Few scored full credit. Common incorrect answers were yeast or ethene as a reactant, and carboxylic acid, carbonate or glucose + water as the additional product.

(ii) The best answers were very short, e.g. ‘biological catalyst’ or ‘protein catalyst’. Many candidates did not refer to the catalyst at all and answers such as ‘a biological thing in the body’ were frequently seen. Several referred to dissolving things in water without reference to catalysts or increasing rate of reaction.

(c) (i) The best answers referred to the optimum rate at 40 °C and clearly indicated that rate increased up to this point, then decreased above this value. Many candidates did not mention the decrease after the optimum temperature had been reached. Others did not write about how the rate of reaction changed. For example: ‘when at 10 °C, the reaction is slow’ or ‘the reaction is only fast around 30-50 °C’.

(ii) A majority of the candidates mentioned one factor that could be kept constant. Few gained two marks. Many did not realise that the energy is transferred at a constant rate and so the time taken does not have to be constant and neither does the amount of fuel burnt. Many mentioned temperature of the atmosphere. This was not credited because this is unlikely to change suddenly in the short duration of the experiment.

(d) (i) Many candidates showed a good ability at plotting points for a graph and drawing a line of best fit. The main errors were **(i)** incorrect plotting of the point for propanol **(ii)** extrapolation to the 40-0 mark **(iii)** drawing a straight line instead of a shallow curve.

(ii) Most of the candidates were able to extrapolate the line correctly. A minority did not draw the line to show the extrapolation. Those who did often gained credit.

Question 6

This question was fairly well answered. The exception was part **(a)(i)** where only about a quarter of the candidates gave a correct response for the source of lead in the air. Good answers were given to parts **(a)(ii)**, **(b)(iii)** and **(d)**.

(a) (i) A few candidates correctly described a source of lead in the air. Many gave answers which were too vague or inaccurate. Common incorrect or vague responses included pencils, melting of metals, factories, chemical waste, and with the carbon dioxide.

(ii) Many candidates correctly described the effect of lead on health. Others wrote vague answers such as ‘breathing problems’, or ‘bad for health’ or incorrectly muddled the effect of lead with those of other atmospheric pollutants such as carbon monoxide (leading to responses such as ‘suffocation’) or sulfur dioxide (leading to ‘acid damages lungs’).

(b) (i) About half the candidates wrote a correct word equation for the reduction of lead oxide. Many did not gain credit because of errors in writing the products. CO was often called carbon oxide or carbon dioxide. A small but significant number of candidates thought that CO was cobalt. A few candidates mistook Pb for palladium.

(ii) Over half the candidates could explain in terms of oxygen loss why lead oxide was carbon. Others gave statements which were too vague to be given credit. For example reduced from PbO to Pb' or 'because it goes from a compound to an element'.

(iii) A majority of the candidates explained that heat is absorbed in an endothermic reaction. Commo errors included 'loses heat', 'lead has a high boiling point', or made reference to bonds breaking.

(c) Many candidates drew a good diagram showing a filter funnel and filter paper with the lead iodide on the filter paper. Others did not draw or did not mention a filter paper. A significant minority misnamed the lead iodide as 'sodium iodide' or 'lead nitrate'. A few drew diagrams of ions or atoms instead of a filtration apparatus.

(d) Many candidates correctly deduced the number of protons, electrons and neutrons. The commonest error was to give an incorrect number of electrons, 204 or 122 being the incorrect numbers seen most often. The neutron numbers were sometimes given, incorrectly, as 82 or 204.

Question 7

About half the candidates scored relatively well on this question. Parts **(d)** and **(e)** were the least well done, with many candidates not knowing the details of the test for chloride ions. A significant number of candidates did not respond to part **(e)**.

(a) A majority of the candidates identified the rod of pure silver as being the anode. The commonest incorrect answer was the iron spoon.

(b) The majority of candidates gained some credit. The commonest correct answer was that the iron spoon was plated with silver. The commonest incorrect answers often referred to theoretical ideas rather than observations. For example, many candidates wrote about ion or electron loss or gain. A significant number mentioned rust.

(c) Over half the candidates gave one or more good reasons why metal objects are electroplated. A minority did not gain credit because they gave vague answers such as 'for protection' or 'to make it a good conductor'. A small number of candidates did not refer to a use and wrote about ions with different charges.

(d) Fewer than half the candidates realised that silver atoms lose electrons when they are converted to silver ions. The commonest error was to suggest that silver atoms gain electrons.

(e) A minority of the candidates gave a full account of the use of silver nitrate to test for chloride ions. Most omitted the use of nitric acid. A significant number gave incorrect additional reagents despite the statement in the stem of the question that silver nitrate is used. Litmus or electrolysis was frequently seen as an incorrect answer. Other common errors included bubbles, and (white) solution.

(f) Most candidates gained partial credit for describing the physical properties of a metal. Many gave high melting or boiling point as an answer, despite these being in the stem of the question. A few mentioned chemical properties rather than physical properties.

Question 8

Most candidates could extract information from the diagram and scored all full credit in part **(a** reactions involved in extracting iron from iron ore using a blast furnace were not well known and only candidates scored full credit in this part. Many candidates could complete the word equation for the reac between iron and hydrochloric acid but fewer could describe the test for iron(II) ions. A significant number o candidates did not respond to parts **(b)** or **(c)(ii)**.

(a) Part **(i)** was almost invariably correct. The occasional incorrect answer was usually **B**. Most candidates obtained credit for part **(ii)**, the commonest error being **D**. In part **(iii)** the commonest errors were either **C** or (less often), **B**.

(b) Many candidates scored some credit but few scored full credit. The majority of the candidates gained their credit from listing the raw materials, even though these may have been out of context. Marks for the stages in the extraction of iron itself were only awarded if they were in a suitable context. Candidates scoring highly generally did so for equations of calcium carbonate decomposition or slag formation rather than from the reduction process. Common errors included suggestions that iron oxide reacts with oxygen to form iron, carbon reacts with limestone to form slag or limestone reacts with iron oxide or reacts directly with sand / silicon dioxide.

(c) (i) Many candidates completed the equation correctly. The commonest error was to suggest water instead of hydrogen.

(ii) Some candidates gave a good description of the test for iron(II) ions using either sodium hydroxide or ammonia. Others knew the test reagent but gave the wrong colour precipitate (usually brown or red-brown). A considerable minority suggested that the test reagent was water and that the water rusts.

(d) A minority of the candidates selected the correct statement about steel. The incorrect discriminator statements were selected in about equal proportions.

CHEMISTRY

Paper 0620/31
Extended Theory

Key Message

There was an increase in the incidence of illegible scripts, mainly due to poor handwriting. Candidates should be reminded that if their handwriting cannot be read, the script cannot be marked. Examiners make every reasonable attempt to decipher the candidate's comments, but ultimately if the meaning is not clear then credit cannot be awarded. It is in the candidate's very best interests to ensure that the responses are clear and unambiguous.

Another cause of concern is ambiguity in a response, for example an indistinct "a" or "e" in ethane/ethene.

Alterations should be made by deleting the original material and clearly writing the changed response.

General Comments

Some candidates were not awarded credit because they had not responded appropriately to the requirements of the question. There was some evidence that candidates were not checking the paper after the required number of questions had been completed. On many scripts, contradictory comments which negated a correct response should have been removed.

The allocated space is normally sufficient to answer the question in enough detail to be awarded full credit. Using extremely small handwriting in order to include a greater content increases the likelihood of contradiction or ambiguity. Filling the entire space, the margins and down to the next question, with comments can make the response even more difficult to read. Candidates have the option of using a blank page at the end of the paper, suitably referenced, if further space is required.

Comments on Specific Questions

Question 1

(a) to **(f)** This question was well answered by the majority of the candidates with many achieving full credit. A frequent error was in **(c)** where a number of candidates gave filtration rather than simple distillation. It is worth noting that in a number of these parts, for example **(a)**, diffusion is an acceptable alternative to fractional distillation.

Question 2

(a) (i) The only common misconception was that solid iodine is brown.

(ii) Almost all candidates stated that melting/boiling points increase down the Group.

(iii) The most sensible prediction for the colour and appearance of astatine, based on the colour darkening down the Group and the increasing melting point, is that it is a black solid. This was correctly deduced by the majority of candidates.

(b) (i) A model answer is 'atoms with the same number of protons but a different number of neutrons or nucleons'. 'Atoms of the same element' was taken to be equivalent to having the same number of protons. The majority were familiar with this definition but inevitably some candidates reversed the equality or negated their comments by stating that they were compounds or molecules.

(ii) Most gave the composition of the atom correctly.

(iii) Almost all correctly identified the element as xenon.

(c) There was quite a mixed response to these calculations, and a number of candidates attempt them. Whilst many gave the correct formula for compound 1, the formula of compo was frequently incorrectly given as FBr_5.

Question 3

(a) (i) Three of the following points were needed:

- more energy
- move faster
- more collisions
- more successful collisions

There were some very good explanations based on the above ideas. Some, however, lost credit by mentioning enzymes.

(ii) A model response was that enzymes work better closer to the optimum temperature and the rate increases. At higher temperatures they are denatured and the rate decreases and becomes zero.

The awarding of the initial credit was quite flexible and would have been awarded for 'rate increases with temperature' or 'the efficiency of enzymes increases with temperature'.

(b) (i) The graph for the catalysed reaction had to start at the origin, have an initial steeper slope and finish with the same volume of nitrogen. Most candidates were awarded at least partial credit.

(ii) Some candidates looked at the volume of nitrogen collected and not the gradient of the graph, and so concluded that the rate increased rather than decreased.

(iii) Very few candidates mentioned concentration which is the major determinant of rate. Many answered the question "why does the reaction stop?".

(c) (i) Candidates would have been more successful if they had separated the formation of the two pollutants. Carbon monoxide is formed by the incomplete combustion of petrol / diesel / hydrocarbons / carbon-containing fuels. The oxides of nitrogen are formed by the reaction of nitrogen and oxygen at high temperatures. This separation would have prevented the inclusion of comments such as 'they are formed by the incomplete combustion of fuels containing carbon and nitrogen'.

(ii) There were many misconceptions seen in the explanations of how a catalytic converter changes these pollutants into less harmful chemical. The catalyst was thought to provide oxygen or become oxidised. Some candidates produced clear accounts of the redox reactions in the converter.

Question 4

(a) This definition proved difficult; it was variously described as a mixture of molecules, a collection of molecules and a small group of molecules.

(b) (i) Most of the candidates managed to list at least two physical properties of these macromolecular oxides.

(ii) The most popular choice was diamond / carbon; other acceptable choices would have been silicon and boron. Graphite was not accepted.

(c) (i) Both oxides are acidic so a reagent which would react with both is a base – sodium hydroxide / calcium oxide / calcium carbonate. An alternative would be a reactive metal which was suggested by some candidates.

(ii) The amphoteric oxide, ZrO_2, would react with an acid. Candidates who had answered **(c)(i)** correctly usually gave correct answers to this part as well.

Question 5

(a) (i) A rate of a photochemical reaction is influenced by light or light energy. Almost a candidates commented on the need for light, for which they were credited, but very few men either rate or energy.

(ii) There are three examples of important photochemical reactions:

photosynthesis
photography
chlorination of alkanes

By far the most popular choice was photosynthesis. There were some excellent answers on this topic resulting in full credit.

(b) (i) The majority of the candidates realised that high pressure would favour the forward reaction, but then failed to explain why.

(ii) There is a much clearer understanding of the effect of pressure on an equilibrium than that of temperature. The required comment was that increased temperature favoured the back reaction or reduced the yield because it is endothermic. The reverse argument, based on the forward reaction being exothermic, was also accepted. These comments were less common than the comparable ones based on pressure in **(b)(i)**.

(iii) Almost every candidate could explain why a catalyst is used. Many responses included correct additional information, which was not required. There is a widespread perception that catalysts reduce the activation energy, which they do not; they provide an alternative route which has a lower E_a, but the E_a of the uncatalysed route remains unchanged.

(c) The standard of the diagrams from a significant proportion of the candidates was excellent. These diagrams need to be carefully presented and checked when completed, which is greatly facilitated by a symmetrical arrangement of the electron pairs.

Question 6

(a) (i) Many candidates could not recall the products of these hydrolysis reactions. Incorrect suggestions were very varied, including lipids, margarine, starch, alkali, energy, alkane and alkene. This list suggests that many may have guessed rather than recall from a secure base of knowledge.

(ii) The names of actual polymers were accepted, for example terylene and nylon. The varied range of responses suggested that improved preparation by many candidates would have been beneficial.

(b) The missing linkages are –NHCO–, –NHCO– and –NHCO–. The monomers are all amino acids.

(c) A model answer, which was awarded full credit, was: ‘By adding bromine water which is orange. If the fat is saturated it will remain orange, however if it is unsaturated it will become colourless.’

Question 7

(a) (i) There were some excellent explanations of why sulfur chloride is a liquid at 25 °C. This is above the melting point but below the boiling point, so it will have melted but not boiled.

(ii) The candidates who adopted the simple approach succeeded. Strontium needs to lose two electrons and sulfur needs to gain two electrons. They both have a valency of 2, and hence formulae of the type XCl_2.

(iii) The acidic compound is hydrogen chloride or hydrochloric acid. Sulfur dioxide or sulfurous acid was accepted. The most frequent error was to suggest sulfuric acid.

(iv) This question proved difficult as many believed that 'strontium is a metal and sulfur is ...' is the explanation for the difference in conductivity. The correct explanation is th... strontium chloride contains mobile ions but liquid sulfur chloride, which is covalent, conta... molecules.

(b) (i) Most were aware that when the acid was used up and the carbonate was in excess the effervescence would cease and a precipitate/residue would be visible.

(ii) A precise answer was required here, i.e. to remove the unreacted/excess strontium carbonate.

(iii) A model answer would be 'it needs water to crystallise; it is a hydrated salt'. The crucial point is that the salt is hydrated and if evaporated to dryness the anhydrous salt would be left.

(c) Many candidates produced exemplary answers for which full credit was awarded. Others used the correct method, but included a single error and so lost some credit. Familiarity with the correct methodology was an essential precursor to the award of any credit.

CHEMISTRY

Paper 0620/32

Extended Theory

Key Message

There was an increase in the incidence of illegible scripts, mainly due to poor handwriting. Candidates should be reminded that if their handwriting cannot be read, the script cannot be marked. Examiners make every reasonable attempt to decipher the candidate's comments, but ultimately if the meaning is not clear then credit cannot be awarded. It is in the candidate's very best interests to ensure that the responses are clear and unambiguous.

Another cause of concern is ambiguity in a response, for example an indistinct "a" or "e" in ethane/ethene.

Alterations should be made by deleting the original material and clearly writing the changed response.

General Comments

Some candidates were not awarded credit because they had not responded appropriately to the requirements of the question. There was some evidence that candidates were not checking the paper after the required number of questions had been completed. On many scripts, contradictory comments which negated a correct response should have been removed.

The allocated space is normally sufficient to answer the question in enough detail to be awarded full credit. Using extremely small handwriting in order to include a greater content increases the likelihood of contradiction or ambiguity. Filling the entire space, the margins and down to the next question, with comments can make the response even more difficult to read. Candidates have the option of using a blank page at the end of the paper, suitably referenced, if further space is required.

Comments on Specific Questions

Question 1

(a) The majority of candidates were awarded credit on this question. Element **C** was almost invariably correctly identified. Trying to name the element rather than just quote the letter given in the question seemed to cause confusion.

(b) The main reason for candidates not gaining credit here was a lack of comparison. 'Niobium is a hard metal' is a true statement but would not gain credit, whereas 'niobium is the harder metal' or 'niobium is a hard metal and rubidium is a soft metal' are both acceptable. Another widespread difficulty was to report chemical differences in the physical area and vice versa.

Question 2

(a) Most candidates identified the correct state.

(b) Some candidates left this blank, possibly because they did not understand what was expected of them. The rest tended to either give the correct states or a correct reversible sign, but less frequently both.

(c) Some candidates did not realise that they were required to <u>name</u> the change of state as opposed to saying the change is liquid to gas.

(d) The idea of pure substances melting and boiling at fixed temperatures was g... understood by candidates.

Question 3

(a) (i) This was often drawn with the C*l* substituting a different H on the same C or on the 3rd C. Sometimes the structure was drawn with a bend in it but with the C*l* still in the same place as the diagram. All three are variants of the diagram on the paper that is 1-chloropropane and not the isomeric 2-chloropropane.

(ii) A minority of the candidates mentioned 'addition reaction' or stated that the propane reacted with hydrogen chloride. The majority correctly gave chlorine as the reactant and said that the presence of light was the essential condition.

(iii) Impure reactants, other gases entering the reaction vessel, or incomplete reactions were frequently given as the reason why the 1-chloropropane was not pure. Hydrogen chloride and 2-chloropropane were recognised as impurities but dichloropropane was rarely mentioned.

(b) (i) Most candidates suggested using acidified silver or lead nitrate and described the formation of a yellow precipitate. Others correctly suggested using a more reactive halogen and described the formation of the brown colour of iodine. A common mistake was to suggest that the starch test would detect the iodide ion.

(ii) The alcohol was usually named as chloropropanol rather than propanol.

(c) (i) The most frequently given answer was the number of drops and the reaction time, but neither of these could be credited as they were both given in the table. The number of drops should have been related to the concentration of the organic halide, and the time to the reaction rate.

(ii) Many candidates talked about reactivity increasing up or down, but unfortunately neglected to add the word 'group' to gain full credit. Also, the relative reactivity of one of the halogens was often compared to its halide with no mention of the other halogens / halides.

(iii) A significant number of candidates answered the question in terms of increasing temperature. Their response was based on the false premise that the rate had increased and did not appreciate the inverse relationship between time and rate. A minority described the reaction as reversible and the equilibrium as being affected by temperature. In contrast, those who interpreted the information given in the question correctly gave some very creditable answers involving energy, particle speed, collision rate and successful collisions.

Question 4

(a) Most candidates gave a correct equation.

(b) (i) Carbon monoxide is made in the blast furnace by the reduction of carbon dioxide by carbon when the supply of oxygen is exhausted. It was incorrectly attributed by some candidates to a reaction between carbon dioxide and oxygen or by the incomplete combustion of carbon.

(ii) There were many equations given showing Fe_2 instead of 2Fe, but otherwise correct.

(c) There were references to impurities without specifying exactly what the impurities were, typically silicon instead of silicon(IV) oxide. The equation for the thermal decomposition of calcium carbonate was given correctly by all candidates, the equation for the formation of calcium silicate proved to be more challenging.

(d) (i) Galvanising was given more frequently than sacrificial protection. Frequent misconceptions were:

zinc can rust
iron loses electrons which are replaced by the zinc
electrons transfer from steel to iron
the importance of zinc oxide as a protective barrier

Question 5

(a) Acceptable uses included:

bleaching (wood pulp/silk/straw)
manufacture of sulfuric acid **or** sulfur trioxide **or** in Contact process
fumigating **or** sterilising
refrigerant
making dyes
making wine
insecticide
fungicide

(b) Most realised that sulfur dioxide is made by the reaction between sulfur and oxygen/air. A few complicated their answer by introducing fossil fuels or volcanoes, yet still managed to gain credit.

(c) Many confused manganate(VII) with dichromate(VI) and gave the colour change orange to green.

(d) Common mistakes were to calculate the mass of sodium sulfite, rather than the volume, use 22.4 dm^3 rather than 24 dm^3, and use the reciprocal, 40 moles of sulfite not 0.025 moles. Despite these adverse comments, significant number tackled this calculation successfully.

Question 6

(a) (i) Candidates were equally divided about the direction of the electron flow.

(ii) There were two acceptable responses to this question: either from the negative terminal of the battery/ power supply or from the anode by the oxidation of iodide ions. Candidates found it difficult to describe one of these alternatives.

(iii) There were some excellent explanations in terms of the mobility of ions in the liquid phase or the immobility in the solid phase. There were some explanations based on electron mobility.

(b) The most frequent errors were copper(II) and hydrogen instead of copper as the cathode product in the electrolysis of aqueous copper(II) sulfate, and potassium instead of hydrogen as the cathode product in the electrolysis of aqueous potassium chloride. Despite these comments, most of the candidates were awarded full or partial credit.

(c) (i) Most of the equations which included the correct reactants and products were correctly balanced.

(ii) The correct insertion in the second space was $4e^-$; most thought it was an element or molecule.

(iii) Candidates seemed to find this explanation difficult and did not relate the increase in concentration to the loss of water, as $2H_2$ and O_2, by electrolysis.

(d) Many candidates assumed that this question on a simple hydrogen/oxygen cell was more complicated. Whereas most gained credit for the electron flow, few gained full credit, probably because candidates thought that the responses were too simple.

Question 7

(a) (i) Most candidates answered this correctly, but sometimes insufficient care was taken writing the formula so it appeared as +1OH.

(ii) The best method is to use the general formula of alkanes to determine the formula of the alcohol with a molar mass of 116 g.

(iii) Many of the diagrams given would have been greatly enhanced by tidiness and symmetry. This would have facilitated checking if the electron pairs were symmetrically distributed around a circle and reduced the incidence of the most common error, the omission of the 2nbps on the oxygen atom.

(b) (i) The main reason for using high pressure is to increase the yield of methanol. The text book answers: high pressure favours the side with the fewer moles of gas which in the product methanol, 1 mole compared with 3 moles of reactants.

(ii) The majority of candidates were awarded the partial credit but then became distracted with economics of the process, specifically the energy cost of using a higher temperature. This is not a valid concern for an exothermic reaction.

(c) (i) Ethanoic acid, rather than methanoic acid, was the most common error.

(ii) The spelling of methyl methanoate had to be correct in order to be awarded credit. It is important that the spelling of chemical names and terms are correct.

CHEMISTRY

Paper 0620/33

Extended Theory

Key Messages

Candidates should be advised to commit definitions (such as molecular formulae) to memory in preparation for the examination in future.

If a candidate wishes to change an answer, they would be advised to cross out the answer that they wish to change and replace it with a new answer. Those who attempt to alter a word by writing over an existing one usually only succeed in making the answer illegible.

On this paper candidates are asked to give uses of various substances, namely chlorine, argon, ethene and oxygen, in **Question 2(a)**, zinc in **Question 4(a)(ii)** and ammonia in **Question 7(a)**. It is advisable that candidates study the syllabus to anticipate similar questions on uses in the future.

Comments on Specific Questions

Question 1

Candidates generally scored very well on **Question 1**. The following points were noted concerning individual parts of the question.

(a) Potassium reacts with cold water to form hydrogen, but the compound that it forms is of the type MOH as opposed to $M(OH)_2$.

(d) Zinc was occasionally thought to be present in stainless steel.

Question 2

Candidates generally scored very well on Question 2. The following points were noted concerning individual parts of the question.

(a) (ii) To state that argon is used in filament lamps is correct, but "used for the filament in lamps" is ambiguous.

(iii) Ethene is made from alkanes (which are used as fuels), because ethene is an important intermediate for the production of a variety of substances such as poly(ethene) and many other organic chemicals. Because it is such a valuable resource it would be wasteful to use it as a fuel.

(iv) Oxygen (as opposed to air) is used to aid respiration in circumstances in which the supply of air is restricted, such as by firemen, mountaineers, deep-sea divers and astronauts or in hospitals where patients have difficulty in breathing. It is incorrect to state that oxygen is used for breathing in normal circumstances. Similarly air contains sufficient oxygen for the combustion of fuels. Oxygen would only be required where a boost to combustion is required, such as in rocket fuels.

Question 3

(a) Many candidates recognised that this question concerned diffusion and correctly referre random movement of bromine molecules. Those who referred to the movement of bro without reference to molecules or particles, gained less credit. The process of evaporation which Br_2(l) changes to Br_2(g) was referred to only very occasionally.

Candidates should avoid the repetition of information from the question. The last line was often repeated.

(b) Some excellent answers which scored full credit were seen. The best answers used the terminology which was provided in the explanation related to Diagram 1. The points that were expected for a good answer referred to:

- the rates of diffusion of hydrogen > air > carbon dioxide
- the pressures inside and outside the pot
- the densities of carbon dioxide > air > hydrogen

Many candidates wrote about pressure without making clear the exact location of this high/low pressure. Some answers ascribed a small/large size to molecules rather than the density. Some candidates described diffusion inside or outside the pot rather than “into” or “out of” which was an ambiguous statement and not credited.

Those who tried to overcomplicate their answers by making reference to other factors usually scored less than the maximum credit available.

Question 4

(a) (i) Most candidates answered this correctly. Zinc was very occasionally not included as part of the answer.

(ii) Many candidates referred to the use of zinc in sunblock and other such skin creams. The question does ask for a ‘large scale use of zinc’ which does not include *compounds* of zinc. Such creams contain zinc oxide. Zinc oxide is used to produce zinc, not the other way around.

(iii) A small number of candidates achieve full credit. Atoms or molecules were often referred to as components of the metallic lattice rather than positive ions. The attraction between positive ions and electrons, (which is the essence of the description of the bond), was seen very occasionally. Most candidates knew that malleability was due to sliding of the (layers of) particles.

(iv) A large number of candidates were aware that different atoms would prevent sliding, although reference to the different size of the atom was less common.

(b) (i) Many candidates knew that zinc oxide could be reduced by either carbon or carbon monoxide, although the requirement for heat was usually omitted. The advantage of using carbon or carbon monoxide is that gaseous carbon dioxide, (which is easily separated from the zinc), is the other product. If a metal which is more reactive than zinc was used, zinc would be produced, but there would be an additional problem of separating the zinc from the solid metal oxide produced at the same time. Hydrogen would also yield a gaseous by-product (steam), but hydrogen is below zinc in the reactivity series, and would therefore be unsuitable.

(ii) This equation was very often correct.

(iii) A small number of candidates achieved full credit. Large numbers knew that the question concerned the reactivity series and knew that zinc was more reactive than silver and lead. Some excellent ionic equations and half-equations were seen. Silver was sometimes seen as Ag^{2+}. The most common misunderstandings usually concerned the involvement of sulfate ions, which were only present as spectator ions.

(iv) There were some very good answers which scored full credit. Candidates were e able to give the materials from which the inert electrodes were made. Carbon would suitable. Zinc was unsuitable as an anode as it is not inert. Copper was referred t question, because it was expected that candidates would have been able to extend knowledge of electrolysis of aqueous copper(II) sulfate using inert electrode to a less familiar parallel example. It was not intended that the electrolyte or the electrodes *contained* copper. Those candidates who thought otherwise would be advised to read the question more carefully. Sulfuric acid was known as a product of electrolysis by only a small number of candidates.

Question 5

(a) (i) This question was answered very well by the majority of candidates.

(ii) There was a tendency to refer to indicators, despite the requirements of the question. Reagents were often non-specific, such as metal or carbonate. Adding an alkali would give no visible observation, and the only way that a (neutralisation) reaction could have been shown to occur, in this case, is by measuring a change in temperature. Magnesium metal or a carbonate such as sodium carbonate would both have resulted in effervescence if added to an acid, and thus would have been a quick and reliable way to test for the presence of an acid.

(b) Some outstanding displayed formulae were seen. Ethyl propanoate was sometimes named and also drawn. It was essential that the word prop**e**noate was written clearly enough to distinguish it from prop**a**noate.

(c) (i) The molecular formula $C_6H_8O_4$ means that one molecule of the organic compound contains 6 carbon atoms, 8 hydrogen atoms and 4 oxygen atoms. Thus the phrase molecular formula is the number of atoms of each element in one molecule of a substance. Very few candidates were able to recall this.

(ii) A carboxylic acid such as ethanoic acid reacts with sodium hydroxide according to the equation

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$

Thus one mole of ethanoic acid reacts with one mole of sodium hydroxide.

Therefore one mole of a carboxylic acid with ***two*** carboxylic acid groups in one molecule would be expected to react with twice as many moles of sodium hydroxide. Therefore the answer required was two moles.

(iii) The –OH group, which is part of the –COOH group, did not qualify as a correct answer. Many candidates gave answers which were other than the 'formula of a functional group'.

(iv) Some outstanding displayed formulae of a variety of correct isomers were seen in response to this demanding question.

Question 6

(a) (i) Many of the answers contained arsenic or arsenic compounds. This probably suggests that candidates could have been more careful in reading the question, because candidates generally have very little problem in recalling or constructing equations.

(ii) This question was almost always correctly answered. Diagrams were generally very clear. Occasionally diagrams were on the small side.

(b)(i) and (ii) These were often answered very well. Some candidates used the atomic number (33) of arsenic instead of its relative atomic mass and/or the relative molecular mass of hydrogen (2) instead of its relative atomic mass.

(iii) Because arsenic is in Group V, it has the same valency as nitrogen and thus does not form double or triple bonds in compounds with hydrogen.

(c) (ii) Proteolytic enzymes such as protease were occasionally correctly given as the answ... many candidates realised that water is responsible for hydrolysis, to use water al... reagent would be extremely slow, which is why aqueous solutions of acids are usually used.

(d) (i) Many elements (and not only transition elements) can have variable oxidation numbers. In ... case the elements in question are copper and arsenic (not arsenate).

(ii) This was often answered very well.

Question 7

(a) The majority of candidates knew that ammonia was connected with the production of fertilisers. Those who merely wrote 'fertilisers' were given full credit, but it would have been better if they had stated that ammonia is used in the manufacture of fertilisers. Ammonia itself is not a suitable fertiliser because of its volatility.

(b) Hydrogen is manufactured for use in the Haber process. Thus there would be very little point in reversing the production of ammonia to produce hydrogen. This was seen in many answers.

Hydrogen is not manufactured industrially by a scaling-up of laboratory preparations such as zinc reacting with sulfuric acid, which was another common answer.

(c) There were many excellent answers to this question, and it was not unusual for full credit to be awarded. Statements such as 'there are less moles in the forward reaction' should be avoided as they do not stipulate whether 'less moles' refers to the right or left hand side of the equation. Candidates are advised to answer in terms of the effect of pressure on rate of reaction and on the position of equilibrium and <u>to keep both parts of the answer separate from each other</u> because rate and equilibrium are not related.

(d) (i) This was very often answered very well. It was not expected that candidates would refer to bond-making or breaking.

(ii) Many candidates scored full credit on this question.

The energy released was frequently calculated as 1164 (3×388), with candidates not recognising that two moles of ammonia are involved. This usually meant that full credit could not be awarded because 1164 is less than 2252 and so the reaction would be shown to be endothermic using these figures.

The phrase 'energy required to form bonds' was sometimes seen, as was 'energy given out when bonds break'. Both are incorrect.

CHEMISTRY

Paper 0620/04

Coursework

General comments

The November entry for this component was, as usual, small.

In the samples of work received, the tasks and the standards applied were completely satisfactory.

Centres are reminded that when marks are submitted for the Coursework component of this syllabus it is a requirement that the work be submitted for moderation.

Centres are further reminded that, in 2010, the procedure for submitting work for moderation changed. Centres are advised to consult an up to date version of the syllabus and use the procedures detailed therein.

CHEMISTRY

Paper 0620/51

Practical Test

General comments

The vast majority of Centres reported no problems with this practical examination and submitted Supervisors' reports with the candidates' scripts. A small minority of Centres were unable to locate the necessary chemicals, while others reported problems completing the questions in the allotted time.

Some excellent responses were seen.

In a number of cases candidates failed to follow the instructions as detailed in certain parts of the questions.

Key messages

Candidates should carefully follow all advice given and read all instructions before starting any experiments.

All observations made during an experiment, such as effervescence when a gas is evolved, should be recorded in the tables provided.

Comments on specific questions

Question 1

(f) The table of results was generally completed by the candidates. A minority of candidates recorded all initial temperatures at room temperature despite having heated the solutions. The final and average temperatures were usually correctly recorded and completed. The times taken for the blue colour to appear were often not recorded in seconds as requested for which candidates lost credit. A decrease in the times recorded was expected as the solutions were heated to increasingly higher temperatures; some unexpected fluctuations in recorded times were seen.

(g) The majority of candidates were able to plot the points on the grid but only a few produced smooth line graphs. Credit was given for best-fit straight lines or a smooth curve. Many graphs were not smooth curves or showed points joined with a ruler in multiple straight lines.

(h) Credit was given for indicating that the average temperature of the reaction mixture would be 72 °C; extrapolation of the graph and correct reading of the time at that temperature was then expected. Many incorrect responses showed guesswork; other candidates did not attempt the question.

(i) The idea of using starch as an indicator or to show the presence of iodine scored credit. Common incorrect answers referred to starch as a catalyst or reagent.

(j) The correct experiment was generally identified but explanations of why this had the fastest reaction speed were often vague. The idea that at a higher temperature particles have more energy or that more collisions take place was required to obtain full credit.

(k) Some candidates appeared to confuse time and speed. Correct responses clearly stated that time for the reaction would increase or that the reactions would take longer; the speed of the reaction would decrease or the reaction would be slower. Responses such as "the time would be slow" scored no credit.

(l) Many good answers stated that using a burette would have been more accurate than using a measuring cylinder.

Question 2

(a) Simple reference to colours such as yellow or green, instead of pH numbers, did not receiv

(b) Both parts of this question were generally well answered, although some candidates did not rec that excess reagents dissolved the white precipitates.

(c) Credit was awarded for realising that this test for halide ions was negative. Responses such as "no reaction", "no change", "no precipitate" and "no observation" all scored credit. Less specific answers such as "nothing" or "clear solution formed" did not receive credit. Unexpectedly, a number of candidates described the formation of white or yellow precipitates.

(e) Most candidates gained partial credit for noting that the litmus paper turned red or became bleached; full credit was given where both observations were recorded.

(f) The quality of responses varied across Centres. A large number of the candidates who did not achieve full credit did not record any fizzing/effervescence and a significant number reported that the gas made a lighted splint 'pop'.

(g) Most candidates successfully identified solid **M** as zinc sulfate; many incorrect responses indicated the presence of aluminium ions and iodide or chloride ions, suggesting that they lacked knowledge and understanding of the tests carried out.

(h) This question was generally well answered; 'hydrogen' was the most common incorrect answer.

(i) Credit was given for recognising the presence of a transition metal compound or oxide. A large number of candidates correctly realised that solid **N** was acting as a catalyst, and some identified it as manganese oxide.

CHEMISTRY

Paper 0620/52

Practical Test

General comments

The vast majority of Centres reported no problems with this practical examination and submitted Supervisors' reports with the candidates' scripts. A small minority of Centres were unable to locate the necessary chemicals, while others reported problems completing the questions in the allotted time.

Some excellent responses were seen.

In a number of cases candidates failed to follow the instructions as detailed in certain parts of the questions.

Key messages

Candidates should carefully follow all advice given and read all instructions before starting any experiments.

All observations made during an experiment, such as effervescence when a gas is evolved, should be recorded in the tables provided.

Comments on specific questions

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(g) The majority of candidates were able to plot the points on the grid but only a few produced smooth line graphs. Credit was given for best-fit straight lines or a smooth curve. Many graphs were not smooth curves or showed points joined with a ruler in multiple straight lines.

(h) Credit was given for indicating that the average temperature of the reaction mixture would be 72 °C; extrapolation of the graph and correct reading of the time at that temperature was then expected. Many incorrect responses showed guesswork; other candidates did not attempt the question.

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(j) The correct experiment was generally identified but explanations of why this had the fastest reaction speed were often vague. The idea that at a higher temperature particles have more energy or that more collisions take place was required to obtain full credit.

(k) Some candidates appeared to confuse time and speed. Correct responses clearly stated that time for the reaction would increase or that the reactions would take longer; the speed of the reaction would decrease or the reaction would be slower. Responses such as "the time would be slow" scored no credit.

(l) Many good answers stated that using a burette would have been more accurate than using a measuring cylinder.

Question 2

(a) Simple reference to colours such as yellow or green, instead of pH numbers, did not receive

(b) Both parts of this question were generally well answered, although some candidates did not rec that excess reagents dissolved the white precipitates.

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(e) Most candidates gained partial credit for noting that the litmus paper turned red or became bleached; full credit was given where both observations were recorded.

(f) The quality of responses varied across Centres. A large number of the candidates who did not achieve full credit did not record any fizzing/effervescence and a significant number reported that the gas made a lighted splint 'pop'.

(g) Most candidates successfully identified solid **M** as zinc sulfate; many incorrect responses indicated the presence of aluminium ions and iodide or chloride ions, suggesting that they lacked knowledge and understanding of the tests carried out.

(h) This question was generally well answered; 'hydrogen' was the most common incorrect answer.

(i) Credit was given for recognising the presence of a transition metal compound or oxide. A large number of candidates correctly realised that solid **N** was acting as a catalyst, and some identified it as manganese oxide.

CHEMISTRY

Paper 0620/53
Practical Test

Key Messages

Candidates should be encouraged to carry out the tests as instructed and not guess the results expected.

Candidates should be instructed to record details of **all** observations in **Question 2**.

General comments

The majority of candidates (total candidature approximately 200) successfully completed both questions and there was no evidence that candidates were short of time. Supervisors reported very few problems with the requirements of this practical examination. The Examiners used the Supervisors' results for **Question 1** when marking the scripts to check comparability.

There was a decrease in the number of candidates giving detailed observations in **Question 2**. There was an unexpected range of different observations recorded in **Question 2** involving candidates from the same Centre.

Comments on specific questions

Question 1

(a) and (b) All of the candidates carried out the two experiments. The tables of results were generally successfully completed. Marks were awarded for recording the initial temperatures of the solutions, **G** and **H**, and then for completing the rest of the boxes with the temperatures increasing and then decreasing.

A minority of candidates had results which were not comparable to the Supervisor's results.

(c) Some candidates did not correctly interpret the scale on the y-axes so marks were lost through incorrect plotting of points. The quality of the smooth line graphs was variable and many were not smooth. Straight lines or smooth curves were awarded credit. A minority of candidates did not label the graphs or labelled them incorrectly because they crossed over each other.

(d) A significant number of candidates had problems with the scale on the x-axis and indicated 8 cm^3 of aqueous sodium hydroxide incorrectly on the graph. Some answers linked a correct tie line to the wrong experiment.

(e) Some candidates described the chemical reaction as endothermic instead of exothermic. Other common, incorrect answers referred to redox or displacement reactions. These responses demonstrated a need to learn the distinguishing features of the types of reaction cited in the syllabus.

(f) (i) A minority of students incorrectly identified the experiment that involved the greatest temperature change; reference to the expected temperatures recorded in the table would have prevented this mistake.

(ii) A significant number of candidates thought that the solution that gave the greatest temperature change was more reactive than the other solution, so scored no credit. Other answers referring to pH and/or different degrees of acidity needed to be more specific to gain the mark

(g) This question was generally well answered. Some candidates wrote statements s… t would be lost to the surroundings and it would cool down' which needed to be more spe… marks.

Question 2

(a) Only a minority of candidates recognised the pale green colour of the solution.

(b) This question was generally well answered, although a significant number of candidates recorded no reaction, or change, when the appearance of a green precipitate was expected. Few candidates followed the last instruction to leave the mixture to stand for five minutes and then note any changes. The minority of candidates who followed the instruction noted the formation of a brown colouration at the surface or on the sides of the test-tube.

(c) This test showed a need for more detailed recording of observations. Good answers included a description of the evolution of a gas, but descriptions of effervescence were often missing.

Incorrect guesses were evident with regard to testing the gas evolved, e.g. lighted splints popping were common, as were descriptions of smells. The gas given off was oxygen and many candidates successfully tested the gas with a glowing splint relighting.

(d) A significant number of candidates did not record the formation of a green precipitate, while other candidates from the same Centre successfully described the change.

(e) Solution **J** was a sulfate and therefore this test should have been negative with no reaction or no precipitate formed being the expected answers. Common, but incorrect, student responses referred to the formation of white and yellow precipitates, or the description of a gas being evolved.

(f) The vast majority of candidates scored full credit.

(g) The appearance of solution **K** was usually well described.

(h) More able candidates were able to describe the formation of a coloured precipitate which dissolved when excess aqueous sodium hydroxide was added.

(i) References to smell were ignored. Most answers showed that indicator paper had not been used. A commonly cited, incorrect answer was to show that a lighted splint popped, demonstrating a need to learn and understand the test for nitrate ions.

(j) Lists of ions such as iodide, chloride, and aluminium were not credited. References to gases evolved in the tests were common and scored no credit.

(k) The presence of nitrate ions in solution **K** was recognised by some candidates. The presence of transition metal cations was only noted by the most able candidates with ammonium ions being a common incorrect conclusion.

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Key messages

Candidates should use a sharp pencil for plotting points and for drawing their lines of best fit on their graphs. This allows them to correct any errors. The question might require the line of best fit to be a curve or straight line as appropriate. Straight lines should be drawn with a ruler, but rulers should not be used to join the points on a curve. Lines of best fit should avoid anomalous points.

Questions requiring candidates to plan an investigation should be answered with details of apparatus to be used, reactants/substances involved and quantitative information clearly specified.

General comments

The vast majority of candidates attempted all of the questions. The full range of marks was seen. The paper discriminated successfully between candidates of different abilities but was accessible to all.

Candidates found **Questions 3** and **6** to be the most demanding.

The majority of candidates were able to complete the tables of results from readings on diagrams and plot points successfully on a grid as in **Questions 2** and **4**.

Comments on specific questions

Question 1

(a) Most candidates achieved full credit. In a few cases, arrows were drawn on the left hand side of the apparatus.

(b) A good discriminating question. More able candidates knew that the colour change was black to brown/red. However, the majority of responses scored no credit because they appeared to confuse the reaction described with the hydration of anhydrous copper sulphate; many references to blue and white colour changes were seen.

(c) A good discriminating question with condensers being selected for use by the more able candidates. The quality of the diagrams varied and some were unlabelled, leading to loss of credit. Answers involving gas syringes or tubes leading into uncooled tubes scored no credit.

(d) Many of the incorrect responses referred to pops, explosions and some sort of reaction. Responses such as "no effect" and "no reaction" did not receive credit as this implied that the lighted splint would remain alight. Creditworthy answers clearly indicated that the lighted splint would be extinguished, with a common response being "would turn it off".

Question 2

(a) Most candidates scored a mark for carbon/graphite or platinum. Copper, zinc and iron were common incorrect answers.

(b) Generally well answered.

(c) Candidates lost credit as a result of vague answers to this question. The idea of e /bubbles or the colour of the solution becoming paler was required. References t occurring, gases being given off and changes of colour did not receive credit.

(d) A good discriminating question. Many candidates did not attempt this question, possibly reflec a lack of experience of practical work.

(d) (i) Good answers referred to the use of distilled water or ethanol.

(ii) Reference to heat e.g. use of an oven or hair drier commonly scored credit. Since the question asked how the electrode could be dried **quickly;** answers involving the sun, paper towels and leaving in a windy room did not score credit.

(e) Although the table of results was often completed correctly, there were a significant number of cases where calculation errors were seen.

(f) Candidates had problems with the scale of the *y*-axis when plotting the points. Three intersecting straight lines were often drawn instead of two as requested. Lines were often drawn freehand and not with a ruler.

(g) Generally well answered, with candidates expressing the idea that the reaction had finished. Answers such as “the mass remained the same” did not receive credit as the response was simply re-stating information supplied in the question.

Question 3

Candidates generally found this question difficult even though the experiment is commonly carried out in schools.

(a) A number of candidates could not describe the appearance of magnesium or magnesium oxide. Many did not attempt a description and inaccurate descriptions such as “brown” and “rust coloured” suggested that candidates may have had very limited experience of practical work.

(b) Often correct; air and oxide were common incorrect answers and some responses appeared to be guesswork.

(c) Some excellent answers discussed letting in more air/oxygen to ensure that the magnesium had fully reacted. A number of candidates thought that the lid was lifted to let gasses or heat escape or to relieve the pressure; showing a lack of understanding of the reaction taking place.

(d) Few answers received full credit. More able candidates realised that reasons could include inaccurate weighing, loss of solid/oxide when the lid was lifted or that the reaction might have been incomplete. Reference to magnesium, oxygen/gasses or heat escaping showed a lack of understanding of the chemistry involved.

Question 4

(a) The table of results was completed correctly by the vast majority of candidates. Many were able to record the temperatures from the thermometer diagrams but some were unable to calculate the average temperatures and subtracted the initial readings from the final readings.

(b) Most candidates plotted the points on the grid correctly. Some candidates struggled to interpret the scale on the *y*-axis. Many graphs drawn were **not** smooth lines and some lines were drawn ‘dot to dot’ with a ruler. A few candidates ignored the instruction given and drew straight lines of best fit. Some graph lines were drawn so lightly that they were barely visible.

(c) A good discriminating question. Some candidates could not read the scale on the *x*-axis. Common errors were to indicate the time at 64^{o}C or 80^{o}C instead of the average temperature of 72^{o}C or not to extrapolate the curve. A number of candidates read from the wrong temperature and a substantial number of candidates could not read the scale on the *y*-axis. The instruction “show clearly on the grid how you obtained your answer” was not followed by a significant number of candidates.

(d) Often correct with candidates realising that the purpose of the starch was as an [illegible] to show the presence of iodine. Common incorrect answers described the function of the [illegible] catalyst, to speed up the reaction or as a reactant.

(e) (i) Generally correct responses.

(ii) Successful candidates scored credit by referring to particles having more energy, moving faster or a greater number of collisions between particles. Many incorrect answers did not refer to the temperature being highest in experiment 5 and made non-specific references to heat thus missing the point that the other experiments also involved heating the reactants.

(f) The more able candidates realised that the time for the reaction would increase and the speed would decrease. It was evident that some candidates were confused between the time taken and the speed of reaction, with a number of answers stating that the “time got slower” and the “reaction would be faster”.

(g) Generally correct, with answers stating that a burette would be more accurate or more precise scoring credit. A minority of candidates who discussed the ease of use of a burette compared to a measuring cylinder received no credit.

Question 5

Answers to this qualitative analysis question varied across Centres. It was evident that some candidates lacked knowledge of the tests required to complete the observations in the table for parts **(a)**, **(b)** and **(c)**.

(a) Many candidates who correctly described the formation of a white precipitate realised that it would be soluble in excess reagent in both parts of the question; although some answers indicated that the precipitates were insoluble. There were a significant number of responses that appeared to be guesses, with references to random colours and the formation of various gases.

(b) Common incorrect answers showed a lack of knowledge and understanding of the test for halide ions and often referred to the formation of a yellow or white precipitate.

(c) This question was well answered with most candidates realising that a white precipitate would be formed.

(g) A number of candidates were able to identify the gas as chlorine. Incorrect responses often appeared to be guesswork with hydrogen, carbon dioxide, ammonia and named anions being common suggestions. Identification of the gas as “chloride” did not receive credit.

(h) The majority of candidates successfully identified the gas as oxygen.

(i) Meaningful conclusions were rare. Oxide ions were sometimes successfully identified but the identity of solid **N** as a transition metal compound was rare. A few realised that the solid was a catalyst and some named manganese(IV) oxide. References to iron, zinc and ammonium salts were common.

Question 6

A good discriminating question. The quality of answers spanned the entire spectrum. Many candidates scored full credit for suggesting the addition of equal masses of limestone and marble to hydrochloric acid.

Despite the information in the stem of the question, a large number of candidates suggested that the limestone and marble should be added to water, scoring no credit. Other incorrect responses suggested the use of chromatography and distillation methods and comparing results.

The best answers referred to using hydrochloric acid to dissolve the two samples, separating the insoluble impurities and comparing the results. Credit was given for:

- measured amounts of limestone and marble
- crushing the samples
- use of **excess** hydrochloric acid
- stir and filtering off impurities

- washing and drying the residue
- weighing the impurities
- comparison of results/conclusion

Some candidates did not refer to the use of limestone and marble in their plans but suggested an experim on calcium carbonate and calcium chloride; showing a lack of understanding of the question. A number o candidates did not attempt this question.

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Key messages

Candidates should use a sharp pencil for plotting points and for drawing their lines of best fit on their graphs. This allows them to correct any errors. The question might require the line of best fit to be a curve or straight line as appropriate. Straight lines should be drawn with a ruler, but rulers should not be used to join the points on a curve. Lines of best fit should avoid anomalous points.

Questions requiring candidates to plan an investigation should be answered with details of apparatus to be used, reactants/substances involved and quantitative information clearly specified.

General comments

The vast majority of candidates attempted all of the questions. The full range of marks was seen. The paper discriminated successfully between candidates of different abilities but was accessible to all.

Candidates found **Questions 3** and **6** to be the most demanding.

The majority of candidates were able to complete the tables of results from readings on diagrams and plot points successfully on a grid as in **Question 4**.

Comments on specific questions

Question 1

(a) Most candidates scored at least one mark. Credit was given for any type of flask, but reference to a 'beaker' was ignored. The measuring cylinder was often wrongly identified as a gas jar. Answers such as 'cylinder' needed to be preceded by the word 'measuring' to be credited a mark. Similarly, 'measuring tube' needed to be more specific to gain credit.

(b) (i) More able candidates discussed the reactivity of copper compared to hydrogen. Many responses discussed the reaction with copper being too slow or too violent, thus demonstrating a need for a more thorough knowledge and understanding of the un-reactive nature of copper.

(ii) The majority of the responses were correct with magnesium, zinc and iron, commonly cited. It was not uncommon for students to select a too reactive metal, with sodium and potassium being favourite choices.

(c) The quality of the diagrams varied and some required labelling. Some candidates did not gain credit because they misunderstood the question and drew a diagram to show another way that hydrogen could be made instead of being collected.

(d) The test and result for hydrogen was often correct, although reference to a glowing splint instead of a lighted splint demonstrated a need for candidates to learn the difference between tests for oxygen and hydrogen.

Question 2

(a) Most candidates scored both marks but some straight lines were freehand and therefore not credited. A few candidates erroneously included the anomalous point.

(b) The extrapolation was often well done, although there were some errors in reading th[illegible] y-axis. Answers that were just guesses, with no extrapolation shown, were insuffici[illegible] credit.

(c) A line to the right-hand-side of the original, passing through the origin, scored credit.

(d) (i) Candidates referring to either a catalyst, or speeding up the reaction, gained the mark.

(ii) This question was generally well answered with candidates realising that lumps had a smaller surface area, so the reaction would proceed more slowly.

Question 3

(a) Some students cited inappropriate pieces of practical equipment, demonstrating the benefit of students doing actual practical work in order to familiarise them with basic experimental apparatus.

(b) Many students correctly answered this question, although others demonstrated a need to learn the rules of salt formation.

(c) (i) Answers such as 'because of safety' or 'to stop evaporation' needed to be more specific to gain credit. Some excellent answers named appropriate gases such as nitrogen dioxide. A number of candidates thought that a fume cupboard was needed to stop the escape of toxic solids or toxic zinc nitrate.

(ii) Only the more able candidates scored credit for the idea of checking for constant mass to confirm that the reaction was complete. The idea of repeating to take an average was a common misconception. Other common responses incorrectly referred to the idea of comparing to the mass in an earlier step, again highlighting the benefit of students conducting and evaluating practical work.

(d) Very few correct answers were seen. Incorrect reference to gases escaping, or the evaporation of zinc oxide, demonstrated a need for a more thorough understanding of the chemistry involved and the limitations of experimental methods.

Question 4

(a) and (b) The tables of results were completed correctly by the vast majority of candidates.

(c) Most candidates plotted the points on the grid correctly. However, some candidates struggled with the scale on the y-axis. Many of the graphs drawn were **not** smooth lines and 'pointy' curves gained no credit. Some lines were drawn dot-to-dot with a ruler, while a few candidates did not label the curves. Some graph lines needed to be drawn boldly enough to see.

(d) Many candidates needed to read the scales on the x-axis and/or the y-axis more accurately in order to gain marks. A common error was to indicate the volume at 9.0 cm^3 instead of 8.0 cm^3. Other candidates needed to identify which experiment to read from.

(e) Many candidates scored credit, although a variety of incorrect answers were seen, e.g. redox, displacement and sublimation. Some confused responses mentioned endothermic or "enothemic".

(f) Part **(i)** was generally correct.

(ii) Most candidates scored credit. Others needed to refer to the different reactivities of the acids instead of their concentrations or strengths.

(d) The majority of candidates realised that the temperature of the solution would return to the initial temperature of 23 $^{\circ}$C or room temperature. However, many didn't explain that this was because the reaction would be finished and so did not gain full credit. Answers such as 'the temperature will decrease' needed to be more specific in order to gain marks.

Question 5

The qualities of answers to this qualitative analysis question were Centre dependent. It was evi some candidates did not have the knowledge of the tests required to complete the observations in ta **(b)** and **(c).**

(a) Some very odd colours were given. Many who correctly stated that the colour was green then described a precipitate or solid despite being were told that J was a solution in the question stem.

(b) A green precipitate was generally well known. Additional incorrect observations such as effervescence did not gain credit.

(c) A range of precipitate colours were cited.

(d) This test for halide ions would be negative with the idea of no reaction or no precipitate being the correct answer. However, yellow or white precipitate formed were common answers that could not be credited.

(e) This was well answered by most candidates.

(i) Most candidates were able to identify the gas as ammonia.

(j) Only the most able candidates scored well on this question. Nitrate ions were sometimes successfully identified but the identity of solution **K** as a transition metal compound was rare. The presence of ammonium ions and copper was often given even though the solution was pink to start with.

Question 6

(a) Some good answers were seen, although a minority of candidates did not attempt this question. Common responses involved named indicators such as litmus or Universal. However, marks were lost by claiming that the indicator goes red in ethanoic acid and blue in ethanol. More able candidates used reagents such as magnesium, metal carbonates and potassium dichromate(VI) or physical tests such as difference in boiling points. A common error was the use of bromine which would not work.

(b) The quality of answers spanned the entire spectrum. Many candidates scored two marks for heating both types of coal. "Burning the coal" needed more detail to be credited.

The best answers involved passing the gases produced through aqueous potassium manganate(VII) and timing how long before the solution turned colourless. Confused answers discussed the degree of colourlessness. Many of those who attempted to discuss the idea of passing the gasses into the potassium manganate(VII) had experimental designs that would not result in the gas going into the solution.

Many candidates tried to collect the gas produced in a gas syringe and measure the volume, but did not appreciate the fact that sulfur dioxide is not the only gaseous product. Other answers discussed collecting the gas and then passing it through potassium manganate(VII) solution and comparing results, which also would not work.

A few answers involved adding additional chemicals such as acid or aqueous potassium manganate(VII) to the coal and then heating the mixture, which did not .

Some candidates did not attempt this question.

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Alternative to Practical

General comments

The vast majority of candidates successfully attempted all of the questions. The full range of marks was seen. The paper discriminated successfully between candidates of different abilities but was accessible to all.

No question proved to be more demanding than the others. All questions discriminated equally well.

The majority of candidates were able to complete tables of results from readings on apparatus diagrams and plot points successfully on a grid as in **Questions 2, 3** and **5**.

Key Message

Candidates should use a sharp pencil for plotting points and for drawing lines of best fit on their graphs. This allows them to correct any errors. A question might require the line of best fit to be a curve or a straight line, as appropriate. Straight lines should be drawn with a ruler, but rulers should not be used to join the points on a curve. Lines of best fit should avoid anomalous points.

Comments on specific questions

Question 1

(a) Both **B** and **D** were accepted as correct answers in part **(i)**, with **A** being a very popular distractor. Nearly all of the candidates realised that the heat should be applied to the liquid. A suitable arrow was accepted on any of the four diagrams.

(b) There was a split in answers here, with most candidates correctly realising that increasing pressure would pop the bung out of the test-tube or crack the glass. Other common responses referred to boiling, which was not credited, as this would happen in all four sets of apparatus.

(c) There were a lot of correct answers, with the use of a syringe being the most common incorrect response.

Question 2

(a) Most candidates knew that hydrogen was the gas produced in the reaction.

(b) The vast majority of candidates could read the gas syringe diagrams correctly.

(c) A well answered question with nearly all candidates plotting the points correctly. A minority of candidates diverted their curves through the anomalous point. Some of the curves needed to be more smoothly drawn in order to gain credit.

(d) (i) The majority of candidates scored full marks for this question.

(ii) Most candidates correctly suggested what the volume should have been. A minority chose 60 cm^3 as the total volume, ignoring "at that time" in the stem of the question.

(e) There were many excellent suggestions as to how the conditions had changed with explanations. Conditions discussed include higher temperature, powdered magnesium and use of a catalyst. The most common error was confusing experiments 1 and 2.

Question 3

(a) The table of results was usually completed correctly, with the exception of the 0.0 cm^3 point, which was actually given in the question. Many candidates recorded this point simply as 0, losing the idea of the precision of a burette.

(b) Most correctly worked out the average of the two closest titration results, which in this question were 23.2 and 23.4.

(c) There was a fairly even distribution in answers between the correct pipette or burette and the insufficiently precise measuring cylinder.

(d) A minority of students gained full credit for this question, highlighting the need for students to learn the colour changes of commonly used indicators.

(e) (i) About half the answers correctly said that the volume of **S** was half that of hydrochloric acid or the converse. Students who simply stated "more" or "less" needed to be more specific to gain credit. Most candidates correctly answered part **(ii)**.

Question 4

(a) As in previous years, qualitative analysis was well known. Most candidates realised that there would be a white precipitate with sodium hydroxide solution, but a significant number thought that it would re-dissolve in excess. Similarly, with ammonia solution, most students correctly said that there would be no precipitate or a slight white precipitate, with a significant few suggesting incorrectly a white precipitate. However, nearly everyone gave a white precipitate with silver nitrate solution in part **(iii)**.

(c) Nearly all candidates correctly identified the gas given off as carbon dioxide.

(d) Most answers identified a carbonate but only a smaller number realised that it was either lead carbonate or silver carbonate. A pleasing number of candidates realised that there were two marks allocated and gave both answers.

Question 5

(a) The recording of the temperatures from the thermometer diagrams was well attempted by nearly all of the candidates.

(b) This question was also well answered, with the majority correctly using a ruler. A few joined the dots rather than drawing a continuous straight line, while others did not plot the point at the origin. A small minority struggled with the scale. A very small number only drew one of the graphs that the question asked for.

(c) Generally, candidates were able to use their graphs to find the required information, although a minority confused the two lines, usually losing both marks.

(d) Most candidates gained the mark for this question.

(e) This question produced some excellent answers. The concise and correct response that zinc was in excess because there was no further temperature rise after 0.8 g was often seen.

(f) This was challenging for most candidates. The most common answer was that the temperature rise would be less, which scored no marks. Only the more able candidates realised that, as copper is less reactive than iron, there would be no reaction and therefore no temperature rise.

Question 6

Whilst most candidates could make an attempt at the question, few scored full marks. There were [illegible] acceptable methods. Probably the best method was to titrate (or add drop by drop) the bromine wat[illegible] the dissolved fat or oil as this would give a clear endpoint when it remains orange. The addition of the fa[illegible] oil to bromine would not give such a clear endpoint, with the orange colour fading away gradually.

Other methods that scored credit involved the rate of decolourisation and the use of a colorimeter to measure the degree of decolourisation.