CHEMISTRY

Paper 0620/11
Multiple Choice (Core)

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

General comments

Some candidates performed reasonably well on this paper.

Questions 1 and **9** proved to be particularly straightforward.

Questions 3, **12**, **27**, **35**, **37** and **40** proved to be more difficult.

Comments on specific questions

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

Question 3

Response **C**. Candidates knew that small molecules were involved but perhaps misunderstood 'high boiling point'. Response **C** was more popular than the correct one

Question 4

Response **D**. Candidates were confused by the inclusion of boiling points, not realising that they were too high for distillation.

Question 7

Response **D**. Candidates missed the word 'mixture'. A compound is by definition not a mixture. Response **D** was more popular than the correct one.

Question 12

Response **B**. Candidates did not know that the reactions were reversible and relied on the fact that a 'reversible' arrow was not present. Response **B** was more popular than the correct one.

Question 14

Response **C**. Candidates knew that melting and boiling were physical changes but not dissolving.

Question 27

Response **C**. Candidates chose the response on the basis of its use and not its property. Response **C** was more popular than the correct one.

Question 30

Approximately equal numbers of candidates selected each response. This indicates that most candidates were guessing.

Question 32

Approximately equal numbers of candidates selected each response. This indicates that most candidates were guessing.

Question 34

Response **A**. Candidates knew that heating was involved but chose the wrong process.

Question 37

Approximately equal numbers of candidates selected each response. This indicates that most candidates were guessing.

Question 40

Response **C**. Candidates knew the monomer but did not realise that the polymer was named poly(ethene), even though it is saturated.

CHEMISTRY

Paper 0620/12
Multiple Choice (Core)

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

General comments

Candidates performed reasonably well on this paper.

Questions 3, **23** and **27** proved to be particularly straightforward.

Questions 16, **17**, **26**, **34** and **39** proved to be more difficult.

Comments on specific questions

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

Question 5

Response **B**. Candidates forgot about the inner pair of electrons in the nitrogen atom.

Question 6

Response **C**. Candidates seemed to misunderstand the ‘7’ in the nuclide.

Question 7

Response **A**. Candidates assumed that alloys are compounds; this was a common error. Response **A** was an equally popular choice as the correct one.

Question 11

Response **C**. Candidates knew that the two processes were different but confused ‘endo’ with ‘exo’. This appeared to be a poorly understood topic.

Question 12

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 16

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 17

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 24

Response **D**. Candidates selected the answer having read the first two bullet points only. It is important to read the whole question.

Question 26

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 30

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 33

Response **B**. Candidates did not know the uses of sulfur dioxide listed in the syllabus. Response **B** was more popular than the correct one.

Question 34

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 39

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 40

Response **C**. Candidates knew the monomer but did not realise that the polymer was named poly(ethene), even though it is saturated.

CHEMISTRY

Paper 0620/13
Multiple Choice (Core)

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

General comments

Candidates performed reasonably well on this paper.

Questions 3, **9**, **27** and **36** proved to be particularly straightforward.

Questions 12 and **40** proved to be more difficult.

Comments on specific questions

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

Question 12

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 14

Response **D**. Candidates did not read the question carefully and assumed that the final stage was a physical change, perhaps reading SO_2(g) as S(g).

Question 24

Response **D**. Candidates selected this answer having read the first two bullet points only. It is important to read the whole question. Response **D** was more popular than the correct one.

Question 28

Response **C**. Candidates did not read the question carefully. Soluble impurities are not removed by filtration.

Question 33

Response **B**. Candidates did not know the uses of sulfur dioxide listed in the syllabus. Response **B** was more popular than the correct one.

Question 40

Response **C**. Candidates knew the monomer but did not realise that the polymer was named poly(ethene), even though it is saturated.

CHEMISTRY

Paper 0620/21
Multiple Choice (Extended)

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

General comments

Candidates performed reasonably well on this paper.

Questions 2, **5** and **20** proved to be particularly straightforward.

Question 9 proved to be more difficult.

Comments on specific questions

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

Question 6

Response **A**. Candidates knew about the different number of neutrons but were unclear about the chemical properties of different isotopes.

Question 8

Response **A**. Candidates knew the phrase 'sea of electrons' but incorrectly thought the lattice was comprised of negative ions.

Question 9

Response **B**. Candidates chose the alternative with the largest number of nitrogen atoms and did not attempt a calculation. Response **B** was much more popular than the correct one.

Question 10

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 15

Response **C**. Candidates did not seem to understand that dissolving is a physical change.

Question 16

Response **A**. Candidates did not read the question properly and answered as if the factor being changed was temperature.

Question 26

Response **D**. Candidates selected the answer having read the first two bullet points only. It is important to read the whole question. Response **D** was more popular than the correct one.

Question 39

Response **C**. Candidates knew the monomer but did not realise that the polymer was named poly(ethene), even though it is saturated.

CHEMISTRY

Paper 0620/22
Multiple Choice (Extended)

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

General comments

Candidates performed well on this paper.

Questions 2, **8**, **23**, **25**, **27**, **30**, **31** and **33** proved to be particularly straightforward.

Question 10 proved to be more difficult.

Comments on specific questions

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

Question 10

Response **A**. Candidates used the mass of calcium carbonate and not the mass of calcium oxide. Response **A** was more popular than the correct one.

Question 13

Response **C**. Candidates knew the processes were different but confused ‘exo’ with ‘endo’. This was a common error.

Question 14

Response **B**. Candidates knew that hydrogen and methane both produce energy but did not appreciate the question related to a fuel cell.

Question 16

Response **D**. Candidates did not read the question properly and answered as if the factor being changed was temperature.

Question 38

Response **B**. Candidates did not realise that the hydration of ethene requires a catalyst.

Question 39

Response **C**. Candidates knew the monomer but did not realise that the polymer was named poly(ethene), even though it is saturated.

CHEMISTRY

Paper 0620/23
Multiple Choice (Extended)

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

General comments

Candidates performed very well on this paper.

Questions 2, **5**, **6**, **8**, **9**, **20**, **23**, **25**, **27**, **30**, **31** and **33** proved to be particularly straightforward.

No questions proved to be especially difficult.

Comments on specific questions

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

Question 14

Response **B**. Candidates knew that hydrogen and methane both produce energy but did not understand the question was referring to a fuel cell.

Question 26

Response **D**. Candidates selected the answer having read the first two bullet points only. It is important to read the whole question. Response **D** was nearly as popular as the correct one.

Question 29

Response **B**. Candidates may have misread the response as it is the melting point of aluminium oxide, rather than aluminium, that is reduced. This response was more popular than the correct one.

Question 39

Response **C**. Candidates knew the monomer but did not realise that the polymer was named poly(ethene), even though it is saturated.

CHEMISTRY

Paper 0620/31
Theory (Core)

Key messages

- It is important that candidates read questions carefully in order to understand what exactly is being asked.
- Better performing candidates write precisely using the correct chemical terminology.
- Some candidates need more practice in revising specific terms which appear in the syllabus and in answering questions involving qualitative tests.
- Interpretation of data from tables and graphs and simple calculations were generally well done.

General comments

Some candidates tackled this paper well, showing a reasonably good knowledge of core Chemistry. Others needed further practice in a wide range of areas especially where states of matter and kinetic particle theory are involved. Nearly all candidates were entered at the appropriate level. A significant number of candidates did not respond to many of the questions, for example **Questions 2(e)** (fermentation), **5(a)(i)** and **5(a)(ii)** (predictions from a table of date), **5(c)(i)** (reactivity of halogens), **6(a)(iii)** (diffusion), and **6(c)** (tests for aluminium and zinc ions). The standard of English was generally good.

Some candidates needed more practice in reading and interpreting questions. The rubric was misinterpreted or ignored by a significant number of candidates in a few questions. For example, in **Question 1(b)(ii)** some candidates only wrote about the arrangement of the particles or the degree of separation but not both. In **Question 2(d)(i)**, nearly all the candidates drew a hydrogen atom instead of a hydrogen molecule. In **Question 2(d)(ii)**, some candidates overlooked the words *type of atoms* and counted up the total number of atoms in the molecule. In **Question 3(a)**, many did not heed the word *other* in the stem of the question and reiterated the method involving weighing. In **Question 3(d)**, a significant number of the candidates paraphrased the statements in the stem of the question rather than giving a different source of carbon dioxide. In **Question 7(a)(i)**, a significant number of candidates misread the question and wrote the names (anode and cathode) for the electrodes instead of the products at these electrodes. Whilst in **Question 7(d)(i)**, many candidates seemed to think that the question was about the properties of metals in general rather than comparing a transition element with a non-transition element.

Some candidates needed practice in answering questions relating to qualitative analysis. For example, many did not know the test for water in **Question 1(a)(i)** or the tests for aluminium ions and zinc ions in **Question 6(c)**. Others needed more practice in learning precise definitions. Many candidates were imprecise when writing the names of chemical compounds. For example, chlorine and chloride were muddled in **Questions 5(b)** and **5(c)(i)**. Imprecise answers were given in **Question 1(b)(ii)** (arrangement and separation of particles in solid and liquid), **Question (2)(e)** (fermentation) and **Question 6(a)(ii)** (diffusion). Some candidates used chemical terms incorrectly. For example, in **Question 3(c)** some candidates referred to time instead of rate.

Many candidates were able to extract information from tables and graphs and balance symbol equations correctly. Most candidates were able to undertake simple calculations involving relative formula mass and calculations involving simple proportion. Others needed to revise these areas.

Questions involving general chemistry including atomic and molecular structure were tackled well by many candidates. Others needed more practice in organic chemistry especially the identification of functional groups, e.g. **Question 2(d)(i)**) and fermentation (**Question 2(e)**. Many candidates also needed to revise the uses of elements and compounds e.g. **Questions 1(a)(iii)** and **2(c)(ii)**.

Comments on specific questions

Question 1

A few candidates identified three or more of the substances correctly in **(a)**. Others seemed to guess the answers; calcium oxide and iodine being seen consistently as answers to many parts of this question. Most candidates were able to identify the correct change of state in **(b)(i)**. Few candidates were awarded full credit in **(b)(ii)**, where the commonest source of error was in muddling the term *arrangement* with the either *separation* or *motion*.

(a) (i) A minority of the candidates knew that anhydrous cobalt(II) chloride turns pink when water is added. The commonest error was to select anhydrous copper(II) sulfate. The incorrect answers calcium oxide or iodine were not unfrequently seen.

(ii) Some candidates recognised that graphite is used as a lubricant. The commonest errors were to select either calcium oxide or iodine.

(iii) A minority of the candidates recognised that calcium oxide is used to neutralise acidic industrial waste. The commonest error was to suggest aluminium.

(iv) Some candidates realised that aluminium is extracted from bauxite. The majority suggested iron.

(v) A minority of the candidates selected a ceramic as being an electrical insulator. Aluminium or iodine were the commonest incorrect answers.

(b) (i) Most candidates identified melting and condensation as the changes of state. The commonest error was to suggest sublimation in place of either freezing or condensation. A considerable minority of the candidates chose boiling as an incorrect alternative to melting.

(ii) Some candidates were awarded two or three marks of the four marks available. The arrangement of the particles in both solid and liquid sodium was not well known. Many candidates did not seem to understand the meaning of the term *arrangement* and wrote about movement instead. In terms of separation, many candidates suggested that in the liquid, the particles were 'apart from each other' or 'not touching'. A significant number of candidates suggested that the particles in a solid vibrate but then went on to state that they do not move very far, which suggests that there is some translation from place to place. A significant number of candidates did not respond to the instruction to write about both arrangement and separation and only wrote about one of these.

Question 2

Many candidates could do simple calculations from given information in **(a)**, balance the equation in **(b)(i)** and link petroleum fractions to their uses in **(b)(iii)**. Most candidates needed further practice in drawing dot-and-cross diagrams (**(c)(i)**) and learning a use of hydrogen (**(c)(ii)**). Others needed to revise aspects of organic chemistry such as the identification of functional groups (**(d)(i)**) and the detail of fermentation (**(e)**).

(a) Most candidates were able to deduce the percentage of nitrogen present in the sample. The commonest errors were associated with incorrect addition of the percentages in the table. The incorrect answer 7.4 was not infrequently seen.

(b) (i) Most candidates were able to balance the equation. The commonest errors were to balance incorrectly with $3O_2$, or 1 or $4H_2O$.

(ii) Most candidates realised that propane is in the same homologous series as methane. The commonest error was to suggest methanol, focussing on the prefix rather than the suffix.

(iii) A majority of the candidates linked the fractions to their correct uses. Candidates obtaining a single mark generally linked either bitumen to making roads or fuel oil to fuel for ships.

(c) (i) Few candidates drew a correct dot-and-cross diagram for a hydrogen molecule. The commonest error was to draw a hydrogen atom. Some of those who did draw a molecule, drew extra non-bonding electrons in addition to the bonding electrons. A minority of the candidates wrote formulae rather than drawing a dot-and-cross diagram. A significant number of candidates did not respond to this question.

(ii) Few candidates gave a suitable use for hydrogen. The commonest incorrect answers were 'for making water', 'petrol' and 'making bombs'. Others wrote vague statements such as 'making chemicals' without specifying a particular reaction or mentioning reduction.

(d) (i) Some candidates recognised the carboxylic acid functional group. The commonest errors were to ring the S–H group or the carbonyl group or not to include the hydrogen of the COOH group. Many candidates put a ring around large sections of the molecule to include the NH_2 group as well as the COOH group. A significant number of candidates did not respond to this question.

(ii) Some candidates counted the number of atoms correctly. Others gave the answer 4, presumably ignoring either the N or S atoms. Some candidates counted the total number of atoms rather than the types of atom.

(e) Some candidates knew about the process of fermentation and wrote about yeast, glucose and anaerobic conditions. Many of the candidates who did recognise fermentation incorrectly suggested that oxygen is required or that a high temperature is needed. A large number of candidates wrote about the addition of steam to ethene but gained some credit by stating some of the correct conditions e.g. room temperature.

Question 3

Most candidates performed well on the calculation in **(b)** and in the rate of reaction question in **(c)**. Fewer gave a convincing argument about how to measure the rate of reaction in **(a)** or to give two other sources of carbon dioxide in **(d)**.

(a) The best answers were given by those candidates who realised that the volume of a gas could be measured using a (gas) syringe and taking the time at particular intervals. A significant number of candidates referred back to the method in the stem of the question and gave weighing methods. Those candidates who did suggest a different method rarely gave details about the equipment to be used. Most candidates referred to timing or referenced the use of a clock or stop-watch. Many suggested timing how long it takes for the reaction to be completed. This was given credit for the timing mark; better performing candidates wrote about taking the times at specific intervals during the reaction.

(b) A majority of the candidates did the simple calculation correctly using simple proportion. The commonest incorrect answers were 9.55 and 6.25 due to incorrect multiplication or incorrect use of the simple proportion method. Other candidates tried to do moles calculations. Candidates should recognise that mole calculations are not required on the Core syllabus.

(c) Many candidates realised that decreasing the temperature decreases the rate of reaction and that increasing the concentration increases the rate of reaction. A significant minority of the candidates suggested that decreasing the temperature increases the rate of the reaction. Others did not gain credit because they wrote about time taken for the reaction or volume of gas given off instead of rate of reaction.

(d) A few candidates gave two distinct sources of carbon dioxide other than an acid reacting with a carbonate or the combustion of carbon-containing compounds. Many repeated the examples given in the stem of the question in other ways. e.g. burning petrol, combustion of fossil fuels. These candidates either did not read the stem of the question well enough or did not realise that petrol and fossil fuels contain carbon. The commonest correct answer was respiration. Some candidates did not gain full credit because they suggested respiration twice e.g. respiration in humans and respiration in animals. The commonest error was to suggest 'photosynthesis' or 'photosynthesis in the dark'.

Question 4

This was the best answered question on the paper. In **(a)**, many candidates deduced the number of sub-atomic particles correctly and in **(b)(i)**, many drew the correct structure for a sodium atom. Many candidates identified the electron in **(b)(ii)** and most deduced the order of reactivity correctly in **(d)**. Fewer candidates gave convincing answers to **(b)** (medical uses of radioactive isotopes) and to **(c)(ii)** (explaining the meaning of exothermic). Part **(c)(iii)** was the least well answered of this question, where many candidates wrote confusing statements or statements which were not specific enough.

(a) (i) The number of protons was usually correct. The commonest errors were to suggest 12 electrons and 11 neutrons or to give the mass number as the number of electrons or neutrons.

(ii) Some candidates knew a medical use of radioactive isotopes. Some candidates did not heed the word 'medical' in the stem of the question and gave industrial or other uses. The commonest incorrect answers were antibiotics, making medicines and nuclear weapons.

(b) (i) Many candidates drew the correct electronic structure of a sodium atom. Typical errors were to draw too few inner electron shells; inner electrons shells as 4,8 or 8,8 or two or eight electrons in the outer shell.

(ii) Many candidates recognised the electron as the particle lost when a sodium atom becomes a sodium ion. The commonest errors were to suggest either a proton or a shell.

(c) (i) Some candidates identified both sodium hydroxide and hydrogen as the products of the reaction between sodium and water. The commonest errors were to suggest sodium oxide in place of sodium hydroxide or oxygen in place of hydrogen. A significant number of candidates suggested substances containing atoms other than sodium, hydrogen or oxygen e.g. sulfur dioxide.

(ii) Many candidates realised that energy is released in an exothermic reaction; fewer focused on the nature of the energy transferred (thermal or heat). A significant minority suggested that heat was absorbed. Others mentioned the energy of the reactants or products without making any comparison. A minority of the candidates wrote about reactivity or other aspects of the reaction rather than considering the energetics.

(iii) A majority of the candidates incorrectly suggested that sodium oxide is an acidic oxide. The best answers referred to sodium oxide being a basic oxide because sodium is a metal and metal oxides are basic. Some candidates suggested that it was the oxygen that caused the sodium oxide to be acidic.

(d) Most candidates gave the correct order of reactivity. The commonest errors were to reverse the reactivity of uranium and lanthanum or manganese and uranium. Very few candidates gave a completely incorrect order of reactivity.

Question 5

Many candidates were able to make appropriate deduction by reference to the table in **(a)** and most could calculate relative molecular mass in **(c)(iii)**. Many candidates needed more practice in naming compounds (**(b)**) and in explaining the reactions of halides with halogens in **(c)(i)**. In **(c)(ii)**, many candidates were able to balance the chemical equation. Fewer were able to give an accurate definition of reduction in **(c)(iv)**.

(a) (i) Many candidates were able to deduce the boiling point of iodine and the density of liquid chlorine from the table of data provided. The commonest errors were to suggest that the boiling point of iodine is below its melting point or to give a value for the density of chlorine well below 1.0. Some candidates gave values which were not credible from the data provided e.g. negative density.

(ii) Most candidates realised that the atomic radius increases down the group. Others wrote vague statements such as 'bromine and iodine have higher boiling points' rather than focusing on the trend in the group as a whole. A considerable number of candidates tried to link the values of the atomic radius to the boiling points or densities.

(iii) Some candidates realised that bromine is a liquid at 50 °C; better responses referred to this temperature being between the melting point and the boiling point. The commonest error was to refer to only the melting point or only the boiling point. Many candidates did not gain credit because they wrote vague statements about not reaching one of the fixed points. A minority of the candidates referred to 50 °C being between the melting point and the boiling point but then suggested an incorrect state.

(b) Some candidates completed at least one of the boxes correctly, generally potassium bromide. Common errors included: potassium salt (instead of potassium iodide or potassium bromide); potassium compound; potassium (unqualified); aqueous potassium. Potassium bromide was most commonly given, even when the candidate suggested potassium iodine for the other reactant. A significant number of candidates wrote potassium hydroxide in place of potassium bromide.

(c) (i) Very few candidates gave a convincing answer to this question. The best answers stated that fluorine is more reactive than chlorine. Common errors included reference to chloride or fluoride or the reactivity of potassium. Many thought that chlorine was more reactive than fluorine. Others just referred to the position of chlorine and fluorine in the Periodic Table rather than their reactivity.

(ii) Most candidates were able to balance the equation. The commonest error was to suggest either 2 or $4F_2$.

(iii) Many candidates calculated the relative molecular mass correctly. The commonest incorrect answer was 120, obtained by using atomic numbers rather than relative atomic masses. Others correctly multiplied the relative atomic mass of fluorine by the number of atoms.

(iv) The best answers referred to removal of oxygen from a compound or gain of electrons. Many candidates gave a non-chemical definition such as ‘making something less’ or ‘decreasing the size’. Others gave imprecise answers such as ‘the oxygen is released’ or ‘the oxygen is reduced’. Other common errors included ‘losing electrons’ or losing atoms’.

Question 6

This was the least well answered question on the paper. In **(a)(i)**, many candidates recognised a neutralisation reaction. Parts **(a)(ii)** (diffusion) and **(b)** (identification of elements present in fertilisers) were less well known. The test for aluminium ions and zinc ions in **(c)** was known by only a minority of the candidates. Many candidates did not respond to **(a)(ii)** and **(c)**.

(a) (i) Many candidates identified the reaction between ammonia and hydrochloric acid as neutralisation. The commonest error was to suggest ‘oxidation’; other incorrect answers were not infrequently seen.

(ii) Some candidates recognised that evaporation and diffusion were occurring. Very few candidates wrote about the particles escaping from the liquid to form a vapour. Fewer explained diffusion in terms of the particles moving randomly from areas of higher concentration to areas of lower concentration. Many just described the fumes moving or the ammonia and hydrochloric acid moving. A minority of the candidates did not recognise the physical process of diffusion and described a chemical reaction between ammonia and hydrochloric acid without mentioning that the particles react when they collide. The best answers included the word diffusion and the idea of particles moving randomly from higher to lower concentrations. A significant number of candidates suggested that the bulk movement of particles was from low to high concentrations. Others suggested that the ammonia and hydrogen chloride were attracted to one another.

(b) Many candidates correctly named one or two elements present in fertilisers. Many candidates gave the names of compounds instead of elements. The compounds were often completely incorrect e.g. carbon dioxide, ethanol, carbonates. Nitrogen was the commonest correct choice. The commonest incorrect elements chosen were calcium, sodium and sulfur.

(c) The best answers referred to both the colours and to the precipitates remaining for the aluminium ions or dissolving for the zinc ions. Many candidates knew that a white colour is formed when aqueous ammonia is added to a solution containing aluminium or zinc ions. Fewer wrote the word ‘precipitate’. The observations on adding excess aqueous ammonia were not well known and some candidates wrote conflicting statements compared with the first column e.g. for the aluminium ions: ‘white precipitate, which dissolves in excess’ (in the left hand column) and ‘precipitate does not dissolve’ (in the right hand column). A few candidates chose colours such as red or green or gave names of chemicals rather than observations. A significant minority suggested that bubbles are formed.

Question 7

Some candidates answered **(a)**, **(b)** and **(c)** well. Others referred to gases or reactive metals being used for the electrodes in **(a)(i)** and gave incorrect electrode products in **(a)(ii)**. In **(c)**, many candidates gave answers that suggested they had not read the stem of the question well enough. The chromatography questions in **(d)** were answered well by most candidates.

(a) (i) Some candidates suggested graphite and gave a good explanation in terms of electrical conductivity or lack of reactivity. Many candidates chose substances for use as an electrode which were gases or reactive metals e.g. ammonia, chlorine, hydrogen, sodium or chromium.

(ii) Some candidates deduced both electrode products correctly. Others gave the correct products but at the reverse electrodes. The commonest errors were to suggest hydrogen or hydrogen chloride at the positive electrode instead of chlorine. Many candidates gave the ions at the electrodes instead of the molecules or atoms, especially chloride at the anode. A considerable minority of the candidates misread the question and gave the answers anode and cathode rather than the electrode products or gave observations such as bubbles formed.

(b) Few candidates were awarded full credit. Many wrote the names of the oxides instead of the metals. A common error was to suggest that magnesium is more reactive than calcium.

(c) A minority of the candidates were awarded full credit. The commonest errors arose because candidates did not read the stem of the question properly and gave general metallic properties or wrote statements about chemical properties which were not sufficiently comparative e.g. ‘magnesium reacts with oxygen’ rather than ‘magnesium is more reactive with oxygen than copper’. Common errors were reference to hardness, electrical conductivity or lustre.

(d) (i) Many candidates recognised that sample **R** contains the same ions as solution **Y** and solution **Z**. The commonest error was to suggest sample **S**.

(ii) Most candidates recognised that sample **T** does not contain the same ions as solution **Y** and solution **Z**. The commonest error was to suggest sample **S**. A significant number of candidates misread the question and chose one of the standards, **Y**.

(iii) A majority of the candidates recognised that sample **R** contained the greatest number of ions. The commonest error was to choose sample **U**.

CHEMISTRY

Paper 0620/32
Theory (Core)

Key messages

- It is important that candidates read questions carefully in order to understand what exactly is being asked.
- Better performing candidates write precisely using the correct chemical terminology.
- Some candidates need more practice in revising specific terms which appear in the syllabus and in answering questions involving qualitative tests.
- Interpretation of data from tables and graphs and simple calculations were generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. Nearly all candidates were entered at the appropriate level; a few candidates gained very high marks. Many candidates answered every part of each question. The exception was in **Question 2(d)(i)** where a significant number of candidates did not respond to the question, which required them to draw a circle around the carboxylic acid functional group. The standard of English was generally good.

Some candidates needed more practice in reading and interpreting questions. The rubric was misinterpreted or ignored by a significant number of candidates in a few questions. For example, in **Question 1(a)(iv)** many candidates did not heed the word 'only' in the stem of the question. In **Question 1(b)(ii)**, some candidates only wrote about the motion of the particles or the degree of separation but not both. In **Question 2(d)(ii)**, some candidates overlooked the words *type of atoms* and counted up the total number of atoms in the molecule. In **Question 7(a)(i)**, a significant number of candidates misread the question and wrote the names (anode and cathode) for the electrodes instead of the products at these electrodes. In **Question 7(d)(i)**, many candidates seemed to think that the question was about transition elements rather than metals in general. Others attempted to write chemical (symbol) equations instead of the word equations requested. Candidates should be advised that a word equation does not include chemical symbols and *vice versa*.

Some candidates needed practice in answering questions relating to qualitative analysis. For example, many did not know the test for halide ions in **Question 5(c)(ii)**. Others needed more practice in learning precise definitions. For example, many did not write a suitable definition of a homologous series in **Question 2(b)(i)** or write a full enough description of thermal decomposition in **Question 3(b)(i)**. Others were imprecise when writing the names of chemical compounds. For example, chlorine and chloride were muddled in **Questions 5(b)(i)**, **5(b)(ii)** and **7(b)** and the correct name of ammonium chloride was rarely given in **Question 6(d)**. Imprecise answers were also given in all parts of **Question 6(b)** about nitrogen oxides. Some candidates used chemical terms incorrectly. For example, in **Question 3(a)(iv)** some candidates referred to time instead of rate. In **Question 7(d)(ii)**, a large number of candidates referred to rusting even though there was no iron present.

Many candidates were able to extract information from tables and graphs and balanced symbol equations correctly. Most candidates were able to undertake simple calculations involving relative formula mass and calculations involving simple proportion. Others needed to revise these areas.

Questions involving general chemistry including atomic and molecular structure were tackled well by many candidates. Others needed more practice in explaining chemical processes especially distillation (**Question 2(e)**) and diffusion (**Question 6(a)(ii)**). Many candidates also needed to revise the uses of compounds and isotopes (**Questions 3(b)(ii)** and **4(a)(ii)**). Others needed more practice in the identification of functional groups (**Question 2(d)(i)**).

Comments on specific questions

Question 1

This question was generally well answered. Most candidates identified at least three of the substances correctly in **(a).** Part **(a)(ii)** (test for sulfur dioxide) was the least well done. In **(a)(iv)**, many candidates did not heed the word 'only' in the question and so did not gain credit. Part **(b)(i)** (changes of state) was answered well by most candidates. Others did not answer the question about the separation and motion of particles in **(b)(ii)** fully enough or suggested that the particles in liquids are well separated.

(a) (i) Most candidates identified octane. The commonest errors were to suggest either aqueous copper(II) sulfate or ethanol.

(ii) This was the least well done part of **(a)**. A minority of the candidates chose the correct answer, potassium manganate(VII). The commonest errors were to suggest either hydrochloric acid or aqueous copper(II) sulfate.

(iii) Many candidates realised hydrochloric acid turns blue litmus red. The commonest error was sodium chloride. A considerable minority chose aqueous copper(II) sulfate.

(iv) Some candidates identified water as the reactant. Others ignored the word 'only' in the stem of the question and suggested hydrochloric acid or one of the other aqueous solutions.

(v) Most candidates identified alcohol as the product of the reaction between ethene and steam. The commonest error was to choose hexane, perhaps because it was another alkene.

(b) (i) Most candidates identified freezing and condensation as the changes of state. The commonest error was to suggest sublimation in place of either freezing or condensation. A few candidates chose heating as an incorrect alternative to freezing.

(ii) The separation of the particles in liquid mercury was the least well known aspect of this question. Many candidates suggested that the particles were 'apart from each other' or 'not touching'. A significant number of candidates did not give an answer to the separation of the particles in the gas. A significant minority of the candidates did not respond to the instruction to write about both motion and separation and only wrote about one of these.

Question 2

Some candidates answered this question well and most were able to manipulate the data in the table in **(a)(i)**, balance the equation in **(b)(i)** and draw a suitable dot-and-cross diagram in (**b)(iii)**. Few candidates gave a suitable definition of a homologous series in **(b)(ii)** or recognised that helium is unreactive in **(c)**. Some candidates needed further practice in identifying the group responsible for decolourising aqueous bromine (**(d)(i)**)**.** Many candidates needed to revise the requirements and conditions needed for fermentation as well as to distinguish between fermentation and the addition of steam to ethene (**(e)**).

(a) Nearly all candidates were able to deduce the percentage of carbon dioxide correctly. The commonest errors were either to give the sum of the substances other than carbon dioxide or to round up the value to 27.

(b) (i) Many candidates were able to balance the equation correctly. The commonest error was to give $2H_2$.

(ii) Few candidates were able to interpret the term *homologous series*. Few mentioned the same functional group and many wrote imprecisely e.g. 'the properties are similar', rather than the chemical properties are similar. It is important that candidates distinguish between the words 'same' and 'similar'. Many candidates wrote about 'same chemical properties' or 'similar functional groups'. Others wrote imprecisely about general formula e.g. 'it has a general formula', rather than the same general formula.

(iii) Many candidates were able to draw a correct dot-and-cross diagram for methane. The commonest errors were to put only one electron in the overlap area; to put extra electrons on the hydrogen atoms; to omit one or two of the bonding pairs of electrons.

(c) Some recognised that helium is unreactive. A majority of the candidates did gain credit because they thought that helium is less dense than hydrogen or 'makes the balloon go higher in the air'.

(d) (i) Few candidates recognised that the C=C bond is responsible for the reactivity with aqueous bromine. The commonest errors were to ring the S=O bond, to include hydrogen atoms attached to the C=C bond (H–C=C–H) or to ring large sections of the molecule to include single bonds and double bonds. A significant number of candidates did not respond to this question.

(ii) Many candidates gave the correct number of distinct types of atom; others forgot the sulfur atom or counted the total number of atoms (19). The answers two and five were often seen as other common errors.

(e) Some candidates knew about the process of fermentation and wrote about yeast, glucose and anaerobic conditions rather than the fractional distillation of ethanol. A large number of candidates wrote vaguely about distillation and some referred to petroleum and ethene. Many gained credit for an understanding of different boiling points. Many also wrote about different melting points. Others gained credit for mention of a condenser and heating the distillation flask.

Question 3

Many candidates performed well in **(a)(i)** (handling information from a graph), **(a)(iii)** (calculation) and **(a)(iv)** (rate of reaction). Others made basic errors in deducing where the rate is greatest (**(a)(ii)**) and in explaining the term *thermal decomposition* (**(b)(i)**). Most candidates needed more practice in learning specific uses of substances (**(b)(ii)**).

(a) (i) Most candidates correctly deduced the time to collect 30 cm^3 of carbon dioxide. The commonest errors were either near misses e.g. 21 s or a factor of 10 difference e.g. 30 or 32 s.

(ii) Many candidates who chose point **P** gave vague explanations referring to more volume of gas or less time, rather than referring to the gradient of the graph. A significant number of candidates suggested an answer 'between points **P** and **Q**'. A significant number of candidates chose points **Q** or **S** and referred to the curve of the graph being greater.

(iii) A majority of the candidates did the simple calculation correctly using simple proportion. The commonest incorrect answers were 49 and 2.36 due to incorrect multiplication or incorrect use of the simple proportion method. Other candidates tried to do moles calculations. Candidates should recognise that mole calculations are not required on the Core syllabus.

(iv) Most candidates realised that increasing the temperature increases the rate of reaction. Fewer realised that using larger pieces of calcium carbonate would lead to a slower rate of reaction. Although an explanation was not required, many candidates incorrectly stated that large particles have a larger surface area. Others did not gain credit because they wrote about time taken for the reaction or volume of gas given off instead of rate of reaction.

(b) (i) Most candidates recognised that thermal means heat. Fewer candidates gave the meaning of the term *decomposition* and just reiterated this word in their answers. Others gave vague answers just referring to 'reactants forming more than one product' rather than a single reactant breaking down (into two or more products).

(ii) This was the least well done part of this question. Many candidates repeated the use given in the question and suggested making calcium oxide. A common incorrect answer was to refer to drinks or vinegar. Energy, fuels and catalyst were other incorrect answers frequently seen. Others just gave the name of a rock 'limestone' or 'chalk' (often blackboard chalk).

(iii) Many candidates did not realise that calcium oxide is basic and so gave answers other than neutralisation e.g. 'decomposition', 'addition'. Others suggested exothermic or endothermic.

Question 4

This was the best answered question on the paper. Most candidates could deduce the correct number of at least two of the sub-atomic particles in **(a)(i)** and draw the electronic structure of calcium in **(b)**. Many candidates needed to revise the uses of radioactive isotopes in industry (**(a)(ii)).** Most candidates were able to apply data from a table to deduce the order of reactivity of the elements in **(c)**.

(a) (i) Many candidates gained full credit for the correct number of sub-atomic particles. The commonest errors were to suggest 24 electrons and 20 neutrons or to give the mass number as the number of electrons or neutrons.

(ii) A minority of the candidates knew an industrial use of radioactive isotopes. Many candidates did not heed the word 'industrial' in the stem of the question and gave medical uses. Others gave uses which could not be regarded as industrial e.g. carbon–12 dating or gave vague answers such as 'making machines work'.

(b) Many candidates drew the correct electronic structure of a calcium atom. Typical errors were to draw too few inner electron shells; inner electrons shells as 2,4,8 or 4,4,8 or one or eight electrons in the outer shell.

(c) Most candidates gave the correct order of reactivity. The commonest errors were to reverse the reactivity of iron and samarium or copper and iron. Very few candidates gave a completely incorrect order of reactivity.

Question 5

Many candidates were able to extract and use information from the table (**(a)**) and to calculate relative molecular mass (**(d)**). A considerable number of candidates were also able to comment on trends correctly (**(a)(ii)**) as well as giving a suitable use for chlorine (**(a)(iv)**). In **(b)(i)** and **(b)(ii)**, some candidates needed to revise the naming of chemical compounds e.g. halogens and halides with special reference to distinguishing between iodine and iodide. Others needed more practice in learning tests related to qualitative analysis e.g. tests to distinguish halides (**(c)(i)** and **(c)(ii)**).

(a) (i) Most candidates were able to deduce the boiling point of chlorine and the density of iodine from the table of data provided. The commonest errors were to suggest that the boiling point of chlorine is below its melting point or above 59 °C or to give too low a value for the density of iodine. A few candidates gave values which were not credible from the data provided e.g. negative density.

(ii) Most candidates realised that the melting points increase down the group. Others wrote vague statements such as 'bromine and iodine have higher boiling points' rather than focusing on the trend in the group as a whole.

(iii) Some candidates realised that bromine is a solid at –20 °C. Others needed more practice at dealing with negative numbers. This was shown by the large number of candidates who suggested that bromine is a liquid at this temperature.

(iv) Most candidates deduced the colour of fluorine correctly. The commonest error was to suggest dark green; a few suggested purple.

(b) (i) Many candidates completed at least one of the boxes correctly. Common errors included potassium salt (instead of potassium iodide or potassium chloride); potassium compound; potassium (unqualified); iodine chloride. Potassium chloride was most commonly suggested, even when the candidate stated potassium iodine for the other reactant. A significant number of candidates wrote potassium hydroxide in place of potassium iodide.

(ii) The best answers stated that fluorine is more reactive than chlorine. Common errors included reference to chloride or fluoride or the reactivity of potassium. Many thought that chlorine was more reactive than fluorine. Others just referred to the position of chlorine and fluorine in the Periodic Table rather than their reactivity.

(iii) Many candidates gave a correct use of chlorine, generally associated with water treatment or swimming pools. Answers which did not gain credit were often too vague e.g. cleaning water.

(c) (i) Very few candidates realised that hydrochloric acid contains chloride ions. The best answers stated that hydrochloric acid contains chloride ions which would give a 'false' precipitate or react with the silver nitrate. Others wrote inaccurately about chlorine ions rather than chloride ions. Many candidates gave answers which were not specific enough e.g. the hydrochloric acid is reactive (without saying what it reacts with). Others wrote about it being not reactive enough or not as reactive as nitric acid.

(ii) The best answers referred to both the colours and to the precipitates. Many candidates knew that a white colour is formed when silver nitrate is added to a solution containing chloride ions. Fewer wrote the word precipitate; some just wrote the colour and others wrote 'white solution'. The colour of the precipitate with iodide ions was less well known, often being given as cream. A significant number of candidates chose colours such as blue or green or gave names of chemicals e.g. chlorine or bromine (even though there are no bromide ions present).

(d) Many candidates calculated the relative molecular mass correctly. The commonest incorrect answer was 676.5, obtained by multiplying 17 by 35.5 for the chlorine with subsequent addition. Others were able to correctly multiply one of the atomic masses by the number of atoms. A few candidates used atomic numbers instead of relative atomic masses.

Question 6

The pH of aqueous ammonia in **(a)(i)** was generally well known and many candidates could balance the equation in **(b)(i)**. Many candidates could explain some aspects of diffusion in **(a)(ii)** and the meaning of the term exothermic in **(b)(ii)**. Fewer could explain how the equation in **(b)(iii)** shows oxidation of nitrogen or in **(b)(iv)** the relationship between acidic oxides and the position of an element in the Periodic Table. Other candidates needed more practice in naming compounds (**(d)**).

(a) (i) Most candidates identified pH as being an alkaline pH. The commonest error was to suggest a pH of 7.

(ii) Some candidates recognised that evaporation and diffusion was occurring. Very few candidates wrote about the particles escaping from the liquid to form a vapour. Fewer explained diffusion in terms of the particles moving randomly from areas of higher concentration to areas of lower concentration. Many just described the smell moving or the ammonia moving. A minority of the candidates did not recognise the physical process of diffusion and described a chemical reaction between ammonia and air. The best answers included the word diffusion and the idea of particles moving randomly from higher to lower concentrations. A significant number of candidates suggested that the bulk movement of particles was from low to high concentrations.

(b) (i) Most candidates balanced the equation correctly. The commonest error was to balance with 2NO instead of 4NO.

(ii) Many candidates realised that energy is released in an exothermic reaction, but fewer focused on the nature of the energy transferred (thermal or heat). A significant minority suggested that heat was absorbed. Others mentioned the energy of the reactants or products without making any comparison. A minority of the candidates wrote about reactivity or other aspects of the reaction rather than considering the energetics.

(iii) The best answers stated that the NO gained oxygen. Others wrote too vaguely about the reaction e.g. 'NO has one oxygen and the NO_2 has 2'. Such statements are not given credit because they just state what is already shown in the equation. Some candidates wrote about electron loss, but candidates should be advised that they have to be specific if this is to be credited. For example, 'the NO gains electrons' is not sufficient because it is not clear which atom is gaining the electrons. For the Core Paper, candidates should be advised not to give their answers in terms of electrons.

(iv) A majority of the candidates suggested, incorrectly, that nitrogen dioxide is a basic oxide. The best answers referred to nitrogen dioxide being an acidic oxide because the nitrogen is a non-metal and non-metal oxides are acidic. Some candidates suggested that it was the oxygen that caused the nitrogen dioxide to be acidic (or, incorrectly, basic).

(c) Many candidates gave a suitable effect of nitrogen dioxide on health but a significant minority gave other effects such as acid rain or 'it has a low pH'. A wide range of incorrect or vague answers were seen including cancer; causes diseases; harmful to brain (confusion with the effect of lead compounds); poisons you or stops oxygen being carried in the blood (confusion with the effect of carbon monoxide).

(d) A minority of the candidates identified the salt as ammonium nitrate. Common errors were ammonia nitrate, ammonium (unqualified) or nitrate (unqualified). A significant minority of the candidates chose ions or molecules which derive neither from ammonia, nor from nitric acid e.g. ammonium sulfate or iodine. Others suggested made up compounds such as 'ammonia nitrate oxide'.

Question 7

This was one of the least well answered questions on the paper. Parts **(a)(ii)** (observations at an electrode) and **(c)** (making hydrated zinc sulfate) were answered well by only a minority of the candidates. In **(d)(ii)**, many candidates did not give comparative answers or wrote about rusting rather than the more general term corrosion. Some candidates could identify the correct electrode products in **(a)(i)**. Others made simple errors or gave answers which suggested they had not read the stem of the question well enough. The best answered parts were **(b)** (completing a word equation) and **(d)(i)** (describing the physical properties of metals).

(a) (i) Some candidates deduced both electrode products correctly. Others gave the correct products but at the reverse electrodes. The commonest errors were oxygen at the negative electrode instead of hydrogen; hydrochloric acid at the positive electrode instead of chlorine. Many candidates gave the ions at the electrodes instead of the molecules, especially chloride at the anode. A considerable minority of the candidates misread the question and gave the answers anode and cathode rather than the electrode products.

(ii) A minority of the candidates gave a correct observation such as bubbles or effervescence. A few gave incorrect observations 'anode goes green' (presumably because of the colour of chlorine) being not uncommon. Others gave the names of substances e.g. chlorine gas or hydrogen gas rather than observations. A small number of candidates wrote about electron loss or gain.

(b) Many candidates identified both zinc chloride and hydrogen correctly. The commonest error was to suggest water instead of hydrogen. Others suggested zinc hydrochloric acid instead of zinc chloride.

(c) A minority of the candidates gained full credit. The commonest errors were to invert either **A** and **E** or **D** and **F**. Many of the candidates who did not gain credit appeared to guess the order and put step **F** or **D** at the beginning.

(d) (i) Many candidates identified two physical properties that are characteristic of most metals, but few identified three distinct properties. Many candidates thought that the question was about transition elements and gave properties such as high density and coloured compounds. Others suggested hardness or strength. These were not accepted because the candidates are expected to know that Group I metals are soft and have low densities.

(ii) The best answers were given by candidates who suggested that alloys are harder, stronger or more resistant to corrosion. Many candidates did not write comparative answers and just suggested 'strong' or 'hard', which could refer to either copper or the alloy. A majority of the candidates did not gain credit for increased resistance to corrosion because they wrote about rusting, which is specific to iron. Others wrote about physical properties of which they did not have any comparative knowledge e.g. 'electrical conductivity' or 'do not apply to all metals e.g. magnetism'.

CHEMISTRY

Paper 0620/33
Theory (Core)

Key messages

- It is important that candidates read questions carefully in order to understand what exactly is being asked.
- Better performing candidates write precisely using the correct chemical terminology.
- Some candidates need more practice in revising specific terms which appear in the syllabus, particularly when answering questions involving qualitative tests and in writing answers to longer free-response questions.
- Interpretation of data from tables and graphs and simple calculations were generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. Nearly all candidates were entered at the appropriate level. A few candidates gained very high marks. Many candidates answered every part of each question. The exception was in **Question 2(c)(ii)** where a significant number of candidates did not respond to the free response question about fractional distillation. In **Question 6(d)(ii)** and **(iii)**, many did not respond to the question about the sources and effects of nitrogen dioxide. The standard of English was generally good.

Some candidates needed more practice in reading and interpreting questions. The rubric was misinterpreted or ignored by a significant number of candidates in a few questions. For example, in **Question 2(b)(ii)** some candidates only wrote about the motion of the particles or the degree of separation but not both. In **Question 5(b)(iii)**, some candidates gave the name of a type of reaction instead the name of a particle. In **Question 7(a)**, a significant number of candidates misread the question and wrote the names (anode and cathode) for the electrodes instead of the products at these electrodes. Others confused the term *observations* (what you see) with the phrase *name the products* (specifying the name of a substance).

Some candidates needed practice in answering questions relating to qualitative analysis. For example, many did not know the test for chromium(III) and iron(II) ions in **Question 6(b)**. Many candidates did not know the chemical test for water. Some candidates needed more practice in learning precise definitions. For example, many did not write a suitable definition of reduction in **Question 8(b)(i)**. Others were imprecise when writing the names of chemical compounds. For example, carbonates were referred to as e.g. sodium carbon dioxide in **Question (6(a)**. Some candidates used chemical terms incorrectly. For example, in **Question 3(d)** some candidates referred to time instead of rate. Many candidates needed further practice at answering extended answer questions such as **Question 2(c)(ii)** (fractional distillation) and **Question 6(c)** (diffusion), especially in terms of ordering their arguments and using correct chemical terminology.

Many candidates were able to extract information from tables and graphs and balanced symbol equations correctly. Most candidates were able to undertake simple calculations involving relative formula mass and calculations involving simple proportion; others needed to revise these areas.

Questions involving general chemistry including atomic and molecular structure were tackled well by many candidates. Others needed more practice in organic chemistry especially the identification of functional groups (**Question 2(d)(i)**). Many candidates needed further revision of the uses, sources and effects of compounds mentioned in the syllabus e.g. sulfur and sulfur dioxide in **Questions 4(d)** and **4(e)(i)** and nitrogen dioxide in **Questions 6(d)(ii)** and **6(d)(iii)**.

Comments on specific questions

Question 1

This question was generally well answered. Most candidates identified at least three of the substances correctly in **(a).** Part **(a)(iii)** (gas formed when limestone decomposes) was the least well done. In **(b)(i)**, many described sublimation but did not gain credit for indicating that no liquid state was involved. In **(b)(ii)**, some candidates gave full answers for both motion and separation of the particles. Others did not answer the question fully enough or only wrote about either the separation or the motion.

(a) (i) Most candidates identified carbon monoxide. The commonest error was to suggest carbon dioxide. Ammonia and chlorine were other incorrect answers which were occasionally seen.

(ii) Most candidates identified propene. The commonest error was methane.

(iii) This was the least well known of the **(a)** questions. Many candidates thought that carbon monoxide or ammonia were formed by the thermal decomposition of limestone.

(iv) Most candidates recognised that chlorine is an element. The commonest incorrect answer was ammonia.

(v) Most candidates realised that sulfur dioxide causes acid rain. The commonest incorrect answers were carbon monoxide or carbon dioxide.

(b) (i) Many candidates realised that sublimation involves a change of state from solid to gas or gas to solid. Fewer gained credit for stating that the change does not involve a liquid or that the change is direct. The commonest error was to suggest that the change of state involved melting or that the substance melted quickly to form a gas.

(ii) The motion of the particles in solid carbon dioxide was the least well known aspect of this question. Many candidates suggested that the particles vibrated but then gave conflicting statements such as 'the particles only move a little away from each other'. Others did not gain credit for the separation of the particles because they wrote vague statements such as 'apart from each other' or 'not touching'. A number of candidates did not give an answer to the separation of the particles in the gas. A significant minority of the candidates did not respond to the instruction to write about both motion and separation and only wrote about one of these. Others wrote about changes of state rather than the absolute state e.g. 'when the solid goes to gas the particles get further apart'.

Question 2

Many candidates could do the simple calculation from given information in **(a)(i)**, balance the equation in **(b)(i)** and link petroleum fractions to their uses in **(c)(i)**. Some candidates needed further practice in drawing dot-and-cross diagrams in **(a)(ii)** and in memorising a chemical test for water (**(a)(iii)**). Others needed to revise aspects of organic chemistry such as the identification of functional groups (**(d)(i)**). Most candidates needed more practice in answering extended answer questions such as those involving fractionation of petroleum (**(c)(ii)**) and writing their answers to such questions in an organised manner.

(a) (i) Nearly all the candidates deduced the percentage of water vapour in the sample correctly.

(ii) Many candidates drew the correct dot-and-cross diagram for water correctly. The commonest errors were to put either one or three pairs of non-bonded electrons on the oxygen or put extra electrons on the hydrogen atoms. Most candidates drew two bonding pairs of electrons between the oxygen atom and the two hydrogen atoms.

(iii) Only a minority of the candidates knew the chemical test for water. Vague statements about bases and salts were seen. Very often, when the correct reagent was given, the essential words anhydrous, blue or white were missing. Others confused the colour changes of anhydrous copper(II) sulfate and anhydrous cobalt(II) chloride. A considerable number of candidates wrote about water having a boiling point of 100 °C, the electrolysis of water or bubbles being formed on decomposition.

(b) (i) Most candidates were able to balance the equation correctly. The commonest error was to attempt to balance with $2H_2$.

(ii) Most candidates realised that butane is in the same homologous series as methane. The commonest error was to select methanoic acid, through the candidates focussing on the prefix rather than the suffix.

(c) (i) Nearly all the candidates matched the correct fraction to its use. Those who obtained one mark usually gained it for the use of bitumen or gasoline.

(ii) The best answers involved heating the petroleum and separating the vapours according to their boiling points with some indication of a temperature gradient in the column or fractions condensing at different heights in the column. Few candidates gained full credit. The difference in boiling points of the fractions was most frequently mentioned. The commonest error was to suggest that separation of petroleum fraction is due to melting points or density. Many suggested heating the incorrect mixture e.g. 'heat the petrol'. A significant minority of the candidates confused the fractionation process with the extraction of iron in a blast furnace. Statements about the condensation of the fractions were often written in too vague a manner to warrant credit and rarely mentioned the change of state from vapour to liquid. Many candidates did not mention the formation of vapours/gases when petroleum is heated. A significant number of candidates did not respond to this question. Many candidates seemed to write their answers in a rather disorganised fashion.

(d) (i) Many candidates recognised the carboxylic acid functional group. The commonest errors were to ring the S–CH_3 group or the carbonyl group or not to include the hydrogen of the COOH group. Many candidates put a ring around large sections of the molecule to include the NH_2 group as well as the COOH group.

(ii) Many candidates counted the number of atoms correctly. Others gave the answer 4, presumably ignoring either the N or S atoms. Some candidates counted the total number of atoms rather than the types of atom.

Question 3

This was one of the best answered questions on the paper. Many candidates performed well in **(a)** and **(c)**. Others made basic errors in not referring to the gradient of the graph in **(b)** or in deducing the effect of reducing the particle size on the rate of reaction in **(d)**.

(a) Most candidates determined the mass of the reaction mixture correctly. The commonest errors were usually near misses or misreading of the scale e.g. 179.25.

(b) Many candidates who chose point **A** did not gain credit for their explanation as they gave vague answers referring to more mass change in less time rather than referring to the gradient of the graph. A significant number of candidates suggested an answer 'between points **A** and **B**' and hence did not gain credit. A few candidates chose point **C** and referred to the curve of the graph being lesser or greater.

(c) A majority of the candidates did the simple calculation correctly using simple proportion. The commonest incorrect answer was 4.41×10^{-3} (obtained by dividing 0.42 by 120 and then multiplying by 1.26). Other candidates tried to do mole calculations. Candidates should recognise that mole calculations are not required on the Core syllabus.

(d) Most candidates realised that increasing the concentration of the acid increases the rate of reaction. Fewer realised that using smaller pieces of magnesium carbonate would lead to a faster rate of reaction. An explanation was not required but many candidates incorrectly stated that smaller particles have a smaller surface area. Others did not gain credit because they wrote about time taken for the reaction or volume of gas given off instead of rate of reaction.

Question 4

Most candidates could deduce the correct number of at least two of the sub-atomic particles in **(a)** and draw the electronic structure of calcium in **(b)**. Nearly all the candidates were able to apply data from a table to deduce the order of reactivity of the elements in **(c)**. Most candidates needed to revise the sources of sulfur (**(d)**) and the uses of sulfur dioxide (**(e)(i)**). Others needed to revise the naming of the products formed in simple chemical reactions (**(e)(ii)**).

(a) Many candidates gained full credit for the correct number of sub-atomic particles. The commonest errors were to suggest 17 electrons and 33 neutrons or to give the proton number as 33.

(b) Many candidates drew the correct electronic structure of a sulfur atom. Typical errors were to draw too few inner electron shells; inner electrons shells as 2,4,8 or 4,4,8 or two or four electrons in the outer shell.

(c) Nearly all the candidates gave the correct order of reactivity. The commonest errors were to reverse the reactivity of gold and copper or copper and tin. Very few candidates gave a completely incorrect order of reactivity.

(d) A minority of the candidates chose a suitable source of sulfur. The commonest errors were to suggest sulfuric acid, sulfur dioxide, combustion (unqualified) or from factories. A significant number of candidates muddled a source of sulfur with a source of nitrogen e.g. lightning or from vehicle exhausts.

(e) (i) Very few candidates gave a different use of sulfur dioxide other than in the manufacture of sulfuric acid. Many gave answers which were imprecise e.g. ‘cleaning products’ or ‘kills plants’. Others gave answers which were not uses e.g. ‘for acid rain’ or ‘in bacteria’.

(ii) Many candidates identified both magnesium sulfate and hydrogen correctly. The commonest errors were to suggest water instead of hydrogen or to suggest magnesium oxide or magnesium sulfide instead of magnesium sulfate.

Question 5

Parts **(a)(i)** and **(a)(ii)** (deductions from table of information), **(b)(i)** (balancing an equation) and **(b)(iv)** (calculation of relative molecular mass) were generally well answered. In **(a)(iii)**, only a minority of the candidates were able to describe the fact that there was no trend in the data and many tried to give explanations. Others needed to revise the basic (or acidic) character of oxides (**(d)(ii)**).

(a) (i) Most candidates were able to deduce the melting point of lithium and the atomic radius of potassium from the table of data provided. The commonest error was to suggest that the melting point of lithium is below that of sodium.

(ii) Most candidates realised that the boiling points decrease down the group. The commonest error was to suggest that they increase.

(iii) Some candidates recognised that there is no specific trend in the thermal conductivity of the Group I elements down the group. The commonest errors were to suggest either that the value of sodium or potassium was too high or that the data was incorrect. Others may have realised that there is no trend but expressed themselves poorly and so could not be awarded credit e.g. ‘the trend is not constant’. Some candidates tried to give explanations and wrote about caesium being radioactive or not knowing its properties.

(iv) Some candidates realised that rubidium is a liquid at 45 °C; better performing candidates referred to this temperature being between the melting point and the boiling point. The commonest error was to refer to only the melting point or only the boiling point. Many candidates did not gain credit because they wrote vague statements about ‘having a melting point but not reaching the boiling point’. A minority of the candidates referred to 45 °C being between the melting point and the boiling point but then suggested an incorrect state.

(b) (i) Most candidates balanced the equation correctly. The commonest error was to write 2Li instead of 4Li.

(ii) Some candidates incorrectly suggested that lithium oxide is an acidic oxide. The best answers referred to lithium oxide being a basic oxide because lithium is a metal or is in Group I of the Periodic Table.

(iii) Many candidates recognised that an electron is lost when a lithium atom forms a lithium ion. The commonest errors were to suggest ‘an atom’, ‘hydrogen’ or ‘oxidation’. The last was presumably a misreading or misunderstanding of the stem of the question and replacing the name of the particle by type of reaction.

(iv) Many candidates calculated the relative molecular mass correctly. The commonest incorrect answers were 2 (using atomic number rather than relative atomic mass) and 156 (obtained by misreading the number of carbon atoms as 12). Others correctly multiplied one of the atomic masses by the number of atoms.

Question 6

This was the least well answered question on the paper. A majority of the candidates could derive a word equation from a symbol equation in **(a)**, explain the use of a catalyst in **(d)(i)** and identify a compound present in fertilisers in **(e)**. Many candidates needed more practice in memorising qualitative tests (**(b)**) and in explaining diffusion using the kinetic particle theory (**(c)**). Others needed to revise the processes which put nitrogen dioxide into the atmosphere and the effect of nitrogen dioxide on health (**(d)(ii)** and **(d)(iii)**).

(a) Many candidates completed the word equation successfully. Others named the carbonates as (di)oxides or even chloride, even though there was no chlorine in the symbol equation. A few candidates suggested mixed names such as sodium carbon dioxide. Most candidates named $Ca(OH)_2$ successfully.

(b) The best answers referred to both the colours and to the precipitates dissolving for the chromium(III) ions or remaining for the iron(II) ions. Some candidates knew that a ‘green colour’ is formed when aqueous sodium hydroxide is added to a solution containing aluminium or zinc ions. Fewer wrote the word precipitate. The observations on adding excess aqueous sodium hydroxide were not well known and some candidates wrote conflicting statements compared with the first column. A significant proportion of the candidates chose colours such as white, red-brown or blue or gave names of chemicals rather than observations.

(c) Some candidates recognised that evaporation and diffusion was occurring. Very few candidates wrote about the particles escaping from the aqueous ammonia to form a vapour. Some explained diffusion in terms of the particles moving randomly from areas of higher concentration to areas of lower concentration. Many just described the ammonia moving along the tube (rather than particles of ammonia). A minority of the candidates did not recognise the physical process of diffusion and although some described the ammonia particles reaching the red litmus paper, few mentioned the particles reacting with the litmus. The best answers included the word diffusion and the idea of particles moving randomly from higher to lower concentrations.

(d) (i) A majority of the candidates explained the use of a catalyst. The commonest errors were to suggest that a catalyst lowers the boiling point, or it neutralises one of the reactants.

(ii) This was the least well answered part of this question. The best answers referred to lightning or fumes from car engines. Many suggested chemical reactions such as burning wood or combustion without realising that for nitrogen to combine with oxygen high pressures (or high voltage) are needed. Other common incorrect answers included decomposition (unqualified), denitrification and bacteria (unqualified). A significant proportion of the candidates did not respond to this question.

(iii) Some candidates gave a suitable effect of nitrogen dioxide on health but a significant proportion gave other effects such as ‘acid rain’ or ‘it has a low pH’. A wide range of incorrect or vague answers were seen including cancer; causes diseases; harmful to brain (confusion with the effect of lead compounds); poisons you or stops oxygen being carried in the blood (confusion with the effect of carbon monoxide).

(e) Many candidates recognised that potassium phosphate is present in many fertilisers. The commonest error was to select sodium chloride.

(f) A minority of the candidates correctly described the reaction as endothermic. The commonest incorrect answer was exothermic. A considerable proportion of the candidates suggested reduction.

Question 7

Many candidates needed to revise how to work out the electrode products during electrolysis as well as deducing at which electrode the products are discharged (**(a)**). Candidates needed to read the question carefully so they did not muddle observations with products. In **(b)**, most candidates had a good knowledge of how the use of aluminium for aircraft manufacture relates to the properties of the metal. Others needed more practice in deducing the order of steps in the making crystals of a salt such as aluminium sulfate (**(c)**).

(a) Some candidates deduced both electrode products correctly. Others gave the correct products but at the reverse electrodes. The commonest errors were hydrogen at the negative electrode instead of aluminium; hydrogen at the positive electrode instead of oxygen. Some candidates gave the ions at the electrodes instead of the molecules. A considerable minority of the candidates misread the question and gave the answers anode and cathode rather than the electrode products or gave observations such as 'bubbles', 'cathode becomes shiny' or 'size of the electrode decreases'.

(b) Most candidates gained full credit. The commonest errors were malleability or conductivity (instead of strong), conductivity (instead of density) and heavy (instead of corrosion). Nearly all the candidates gave density as the correct answer in the second space.

(c) A minority of the candidates gained full credit. The commonest errors were to invert either **F** and **A** or **E** and **B**. Many of the candidates appeared to guess the order and put step **C** or **E** at the beginning.

Question 8

This was the best answered question on the paper. Many candidates answered most parts of this question well, especially the chromatography questions in **(a)**. Some candidates needed to revise the meaning of the term reduction (**(b)(i)**). Others did not recognise that oxidation is the opposite of reduction (**(b)(ii)**).

(a) (i) Most candidates identified mixture **U**. The commonest error was to suggest mixture **S**.

(ii) Nearly all the candidates selected the correct mixture, **T**. The commonest error was to select mixture **S**.

(iii) Many candidates identified the correct mixture, **T**. The commonest errors were either to select mixture **S** or mixture **W**.

(b) (i) Some candidates gave a correct definition of the term reduction, in terms of loss of oxygen. The commonest errors were to suggest loss of electrons, loss of an atom or gain of oxygen. A considerable proportion of the candidates did not give a chemical definition and gave answers such as 'it reduces the size of something'; others referred to colour changes.

(ii) Some candidates realised that oxidation is the opposite of reduction. Others suggested an incorrect alternative; polymerisation being the most popular of these.

CHEMISTRY

Paper 0620/41
Theory (Extended)

Key messages

- Candidates must read questions carefully to ensure that the answer they give addresses what has been asked. Information contained within a question can sometimes be very useful when trying to answer the question.
- Where a question asks for the name of a compound, candidates would be well advised **not** to give the formula in place of a name, as an incorrect formula cannot gain credit.
- Carbon forms four covalent bonds and hydrogen one; errors in the numbers of bonds formed by atoms in organic molecules were common.
- When giving conditions for a reaction, candidates should avoid giving ranges of temperatures and pressures. If a range is given, then both the upper and lower limits of that range must fall within the correct range.

General comments

The vast majority of candidates completed the entire paper in the allocated time. Although it was not uncommon for candidates not to attempt some parts of the paper.

Candidates who read the questions carefully and had prepared for the examination thoroughly produced some excellent answers, which were well structured and detailed.

In **Question 4,** candidates needed to use their knowledge of precipitation reactions combined with the information in the stem of the question. A common error was for candidates not to use the information provided and so some very poor answers were seen to the question as a whole.

Comments on specific questions

Question 1

(a) (i) The majority of candidates were able to correctly state that K^+ ions gave a lilac colour in a flame test.

(ii) Many responses incorrectly stated that Cu^{2+} ions would give a grey-green precipitate.

(iii) A common error was to suggest an anion would form a precipitate with sodium hydroxide.

(iv) The correct response, Br^-, was given by many candidates. Cl^- was a common error.

(v) The test for sulfate ions was not well known, with many candidates suggesting that this test identified sulfite ions.

(b) Some excellent answers describing the use of a nichrome wire, which was first cleaned in hydrochloric acid, were seen. However, many candidates could not state correctly how the solid was introduced into the Bunsen flame. The use of a wire or wooded splint was required; many candidates incorrectly suggested the use of spoons or tongs. Some candidates seemed to be describing gas tests by using a lighted splint rather than the flame from a Bunsen burner.

(c) Many fully correct formulae were seen.

Question 2

(a) Some candidates were able to give clear and concise definitions for the term *isotopes*. The majority of answers omitted the key word 'atoms' and referred instead to elements or compounds.

(b) (i) This was well answered. The most common error was not to take into account the charge on the sulfide ion.

(ii) This was well answered. Common errors were to omit the number of electrons that need to be gained or to state that electrons are lost.

(iii) Many correct answers were seen. A significant number of candidates were unable to deduce that if the 2+ ion had 18 electrons then the atom must have 20 electrons and so the atom was calcium.

(c) (i) Better responses gave three correct state symbols. Common errors included giving the state symbol for sulfur as (aq), despite it being stated as molten in the information provided. A number of candidates used capital letters for the state symbols; these are not accepted. A significant number gave numbers or letters that are not state symbols.

(ii) Fully correct responses were not uncommon. Some candidates just missed out on the name of the catalyst by not giving the oxidation state of vanadium. Others mixed up the manufacture of sulfuric acid with other industrial processes.

(iii) Some candidates gave two correct equations. Errors in the formula of oleum were seen, despite this being in the information in the stem of the question. It was evident that some candidates did not know the formula of sulfuric acid.

(d) (i) Most candidates gave one correct environmental reason. Sulfur dioxide was often incorrectly stated to be a greenhouse gas. It is not considered to be a greenhouse gas, although when it forms acid rain this will react with limestone to make carbon dioxide, which is a greenhouse gas. It is not ozone depleting. Answers based on respiratory problems were not credited as the question asked for an environmental reason.

(ii) The best answers gave a fully correct description of the test for sulfur dioxide. Only a small minority of candidates could fully describe this test. A large proportion of candidates did not attempt this.

(e) Some well set out, clear and fully correct calculations were seen. A common error was to round the 1 : 1 : 1.5 ratio to 1 : 1 : 2 rather than double it to 2 : 2 : 3

Question 3

(a) This was well answered. It should be noted that when 'high melting point' is given as one property, high boiling point' is not accepted as the other property, since if the melting point is high it follows that the boiling point must also be high.

(b) Most candidates could identify water and oxygen as being required for iron to rust. A common error was to state hydrogen was required in place of water.

(c) (i) Many fully correct answers were seen that included the essential comparison to the reactivity of iron.

(ii) The oxidising agent, reducing agent, species oxidised and species reduced must all be on the left hand side of a chemical equation. It was clear that there was some confusion between something being oxidised and something being an oxidising agent. Some candidates suggested that if a species gained electrons, it became a positive ion.

(d) This question required candidates to recall that an amphoteric compound will react with both acids and alkalis and then to give the name of an acid and of an alkali as suitable reagents. In both cases, the observation should be that the solid zinc oxide would dissolve. Many candidates did not give observations as required by the question but just stated 'reacts'. Many who did try and give observations incorrectly stated there would be fizzing.

Question 4

(a) (i) The aqueous cobalt salt only formed a precipitate with aqueous sodium carbonate, hence the precipitate formed had to be either sodium nitrate or cobalt carbonate (the two products). In the stem of the question, candidates were told that all sodium salts are soluble in water – hence the precipitate, and so the insoluble cobalt salt, must be cobalt carbonate. Some correct answers were seen. Other candidates did not gain credit as a result of trying to give the formula of cobalt carbonate rather than the name. Credit cannot be awarded for an incorrect formula as it does not represent the correct compound. Many answers identified the insoluble cobalt salt as a compound that did not contain cobalt.

(ii) The only reaction involving an aqueous lead salt that produced a yellow precipitate was the reaction between aqueous lead(II) nitrate and aqueous sodium iodide. Hence, the yellow precipitate was lead(II) iodide. Many candidates who had correctly identified lead(II) iodide as the yellow salt did not gain credit as they gave an incorrect formula.

(b) Some fully correct equations were seen. The most common error was to give an incorrect formula for silver carbonate. This resulted in no credit for many candidates. Those candidates who could write the correct formula for silver carbonate often then did not balance their equation.

(c) Only the better performing candidates could write a correct ionic equation for the reaction. Most candidates did not start with lead ions and iodide ions on the left hand side.

(d) Candidates are not expected to be able to recall why the silver nitrate is acidified in the test for halide ions. However, sufficient information was provided in the question to enable candidates to apply their knowledge of the reactions of carbonates with acids and deduce why the silver nitrate should be acidified. Very few correct answers were seen.

Question 5

(a) (i) Better performing candidates were able to identify the type of polymer shown as an addition polymer. It was evident that some candidates did not read the question carefully and tried to name the polymer.

(ii) Better performing candidates were able to correctly give the empirical formula of the polymer. Some candidates either did not read the question carefully or did not understand the meaning of 'empirical' and so tried to give the molecular formula of either the whole section shown or of the repeat unit.

(iii) Some fully correct structures of 2,3-dimethylbut-2-ene were seen. Many candidates, rather than draw the structure of the monomer, tried to draw the structure of the repeat unit and so drew structures that lacked the essential C to C double bond.

(b) (i) Many candidates were able to give a fully correct explanation of the term *structural isomer*. Most candidates were able to gain credit for identifying that the isomers would have different structures; far fewer were able to state that they would have the same molecular formula. Common incorrect terms used in place of molecular formula were 'chemical formula', 'empirical formula' or just 'formula'.

(ii) The majority of candidates were able to gain credit for drawing butane. Some candidates could draw methyl propane. It was very common for candidates to draw two versions of butane, with one being shown with a bent chain.

(iii) Some excellent equations were seen, including a few that involved both CO and CO_2 as products. Some candidates tried to write equations for the complete combustion, which indicated they had not read the question carefully. It was common for equations to have hydrogen as a product or to just add the oxygen onto the butane molecule.

Question 6

(a) Many fully correct and well set out answers were seen. A common error was in orders of magnitude – possibly due to an incorrect conversion from cm^3 to dm^3.

(b) Many correct answers were seen for this moles calculation. The most common error was in orders of magnitude.

(c) (i) Many candidates were able to correctly calculate the relative molecular mass of HBr and then multiply this by the concentration in mol/dm^3 to obtain a concentration of $720\,g/dm^3$. A common error was to just restate the concentration given in the question as the answer.

(ii) Better performing candidates were able to link the ability to conduct electricity with the mobility of hydrogen ions and bromide ions. A very common error was to state that electrons were able to move and that HBr can conduct electricity because bromine is a metal (which it is not) and that metals can conduct electricity.

(iii) Most candidates were able to correctly state that magnesium is not inert or that it would react. A common incorrect answer was that it is not a good enough conductor.

(iv) The correct answer was commonly seen. Common errors were hydrogen and 'Br' - the product is bromine which is Br_2.

(v) Many candidates made some progress with this half-equation. Some did not gain credit as a result of diatomic hydrogen ions or hydrogen ions with an incorrect charge.

Question 7

(a) The vast majority of candidates were able to make some progress with this question. Credit was most commonly awarded for the use of yeast and a suitable temperature. Relatively few candidates stated that water was required (to form an aqueous solution of glucose) and the equation was often wrong. It was not uncommon for candidates to fail to state how ethanol, suitable to use as a fuel, could be obtained from the reaction mixture or to misunderstand the question and describe the hydration of ethane to obtain pure ethanol.

(b) Many correct answers to the bond energy calculation were seen. A common error in calculating the energy required to break bonds was to omit the C–C bond from the calculation. The sign of the final answer is important and most candidates correctly subtracted the energy released figure from the energy needed figure.

(c) (i) Almost all candidates were able to state that a catalyst increased the rate of a reaction. Considerably fewer went on to state that the catalyst remained unchanged at the end of the reaction. It should be noted that the statement 'the catalyst is not involved in the reaction' is not creditworthy – the catalyst must be involved in some way or it would not be able to increase the rate.

(ii) Many completely correct dot-and-cross diagrams were seen. Common errors included omitting the non-bonding electrons on oxygen or showing only a single bond between carbon and oxygen.

(iii) Many correct answers comparing the strength of the intermolecular forces in ethanol and ethanal were seen. Common errors were to imply or state that covalent bonds were breaking; to fail to be comparative in the answer (simply stating the intermolecular forces were weak did not gain credit as both ethanol and ethanal have weak intermolecular forces and this does not explain the difference in boiling point); or by carelessness, giving an answer in which ethanal was compared to ethanal (itself).

(d) (i) This question asked for candidates to 'state and explain'. Better responses did this by stating the equilibrium would move to the right and then explained why in terms of the relative numbers of moles on each side of the reaction. Common errors included a confusion between left and right or stating that the position of equilibrium increases – this is meaningless and cannot gain credit. Any comments on the rate of the reaction were ignored as the question did not ask about rate.

(ii) This part of the question was about rate of reaction and any comments on equilibrium were ignored. While most candidates were aware the rate of reaction would increase, relatively few were able to explain why. Two points needed to be made – firstly, that there would be more frequent collisions and secondly, that this was because the particles were closer together.

(iii) Better responses correctly stated the position of equilibrium would move to the left and linked this to the fact that the backward reaction is endothermic. Many answers incorrectly started the equilibrium would move right because the reaction was faster and so more ethanol would be made.

CHEMISTRY

Paper 0620/42
Theory (Extended)

Key messages

- Candidates must read the questions carefully to ensure that the answer they give addresses what has been asked. This was true of **Question 1**, which required responses only from within the first 36 elements of the Periodic Table.
- When a chemical equation is asked for, this means a balanced symbol equation using correct symbols/formulae and not a word equation. Word equations were frequently seen in **Questions 2(f)**, **3(a)(ii)**, **3(b)(iii)** and **5(a)(ii)**.
- Candidates who performed less well had not learnt the definitions and statements within in the syllabus. This was seen in **Question 2(a)**, which asked for the percentage of clean, dry air which is nitrogen; **Question 2(g)(iii)**, which asked for the two ways of hydrolysing complex carbohydrates into simple sugars and **Question 3(b)(i)**, which asked for the meaning of the term *base*.

General comments

There were some excellent responses. Most candidates appeared to be well prepared for this paper, with only a very small proportion who may have been better advised to sit the Core paper.

There were few blank spaces. The fuel cell and the catalytic convertor were often not well known.

Far fewer candidates gave multiple responses, as very few lists were seen. Most candidates attempted to show full working in the two calculation questions, which is a good examination practice.

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

Very few candidates felt the need to write on extra pages. If extra pages are used, the questions must be clearly numbered.

Comments on specific questions

Question 1

This was based upon various parts of the syllabus and required a knowledge of the chemistry of the first 36 elements.

(a) (i) to (vii)

In general, candidates performed well. Common errors, presumably caused by mixing up mass number with atomic number, were **(i)** beryllium; **(iii)** sodium and **(iv)** oxygen.

Other frequent errors, presumably caused by candidates not appreciating that the data given referred to ions (not atoms) of an element were **(v)** argon and **(vi)** neon.

(b)(i) Francium was a very common error caused by candidates not appreciating that it was the first 36 elements only that were being asked about.

(ii) Candidates knew that calcium reacts with air to form lime.

(c) (i) It was quite well known that hydrogen was the fuel used in a fuel cell.

(ii) Very few candidates were aware that the behaviour of hydrogen within a fuel cell was equivalent to the combustion of hydrogen. Instead, many gave attempts at ionic half-equations which had hydrogen as a product.

Question 2

This was based around upon the 'Air' section of the syllabus.

(a) Most knew that 78 per cent of clean, dry air was nitrogen. Many gave the answer as 79 per cent, presumably subtracting oxygen's 21 per cent from 100 per cent and ignoring the presence of noble gases.

Weaker responses included incorrect percentage composition calculations.

(b) Most candidates knew separation of oxygen was achieved by fractional distillation of liquid air.

(c) Most candidates knew that the major adverse effect of SO_2 was acid rain.

(d) Many candidates realised that combustion of atmospheric nitrogen within a car engine released oxides of nitrogen into the atmosphere. Often responses did not mention that it was the extreme heat of the engine that allowed this combustion to happen.

Weaker responses assumed, erroneously, that nitrogen was in the fuel used.

(e) Many candidates knew that a catalytic converter changed CO and NO into carbon dioxide; few realised that nitrogen was the other harmless product. Nitrogen dioxide was frequently seen. The the identity of the catalyst was not well known; platinum, and either rhodium or palladium were accepted. Iron or nickel were the most common of the frequent incorrect responses.

(f) Some very good chemical equations were seen. One common error was to have hydrogen instead of water as the other product. Some candidates incorrectly wrote word equations.

(g) (i) Both scientific terms were well known.

(ii) The structure of the complex carbohydrate formed from three units of glucose was generally well known, with correct linkages frequently seen. Some candidates did not show continuation bonds.

(iii) In general, the two ways of breaking complex carbohydrates into simple sugars were not known.

(iv) Chromatography was frequently seen.

Question 3

This was based around the chemistry of ammonia.

(a) (i) The symbol for a reversible reaction was almost universally known.

(ii) Some very good answers were seen and it was not uncommon to award all five marks. The essential conditions for the Haber process were generally well known; occasionally units were missing. A significant proportion of candidates did not gain credit for the chemical equation. Weaker responses gave a word equation and occasionally 'N' was seen as the (incorrect) formula of nitrogen. The chemical equation was also omitted completely in some cases This was frequently the case where candidates had produced longer, unfocused answers.

Better responses were concise and stated '450°C; 200 atmospheres pressure; iron catalyst. $N_2 + 3H_2 \rightarrow 2NH_3$' and gained full credit.

(iii) The source of hydrogen used in the Haber process was well known.

(b) (i) The meaning of the term *base* was well known by many candidates.

(ii) Most candidates knew that the Contact process is used to manufacture sulfuric acid.

(iii) The chemical equation for the reaction between ammonia and sulfuric acid is challenging and relatively few candidates gained full credit. Errors included introducing water as a second product, despite no oxygen being present in the reactants. Others felt hydrogen was a second product. Many wrote the correct formula for ammonium sulfate but did not balance the equation.

(c) (i) Very few candidates could identify the green precipitate as iron(II) hydroxide.

(ii) Very few candidates identified the green precipitate; the majority knew that atmospheric oxidation converted an iron(II) compound to an iron(III) compound.

(iii) Most candidates knew the green precipitate remained when excess aqueous ammonia was added to it. Some weaker responses gave contradictory descriptions, such as 'it dissolves and remains'.

(d) (i) This unstructured calculation involving molar gas volumes was done very well. A variety of correct methods were seen.

(ii) Error carried forward could often be applied if candidates showed their working clearly. Some candidates correctly used the equations coefficients. The most frequent error was to omit the division by four to calculate the energy change when one mole of NH_3 reacts.

Question 4

This was based upon electrochemistry.

(a) Frequently the *type* of particle, i.e. 'ions', was given as being responsible for the passage of electricity in molten copper(II) bromide rather than the identity of the actual ions present.

(b) (i) Although incorrect, 'graphite' was the most frequent answer seen, presumably as a result of candidates not reading that the name of a **metal** was required.

(ii) Most candidates knew chlorine was formed at the positive electrode.

(iii) The majority of candidates realised that H^+ ions receive electrons. Better responses went on to balance the ionic half-equation but the correct state symbols were often incorrect.

(iv) Better responses stated that the pH (which is a number) *increased* and went on to explain this was because an excess of hydroxide ions remained in solution (usually expressed as 'sodium hydroxide forms'). These then went on to relate the presence of hydroxide ions causing solutions to become alkaline.

(c) (i) Candidates found this seemingly straightforward question challenging. The error of showing electrons travelling from copper to zinc was frequently seen; weaker responses often showed electrons in the solution.

(ii) This question was well answered in general. Some responses stated 'iron is less reactive', which was too vague for credit to be awarded. The name of the element (zinc or copper), which is less reactive than iron was required.

(iii) Vague responses were common and did not gain credit. It was expected that candidates would write that silver is less reactive than copper.

Question 5

This was based upon organic chemistry.

(a) (i) Better responses knew that ultra-violet light was the essential condition.

(ii) Candidates found the chemical equation for the reaction challenging.

(iii) Better responses knew this was a substitution reaction.

(iv) The completion of this equation was almost universally correct.

(b) The majority of the candidates performed well in this question. The frequent error was the omission of the non-bonding electrons on oxygen.

(c) (i) The majority of candidates knew the name of the ester formed was methyl propanoate.

(ii) Most candidates knew water was formed alongside the ester.

(iii) Many candidates did not read the question correctly. They were asked to draw the structure of an *ester*, which is an *isome*r of methyl propanoate.

The most frequent error seen was to draw the structure of methyl propanoate rather than one of its isomers. As this had a molecular formula of $C_4H_8O_2$ and an ester link, two marks could be awarded. The next most common error was to draw chemically correct structures of $C_4H_8O_2$, which did not have an ester link, e.g. butanoic acid or 2-hydroxy butanal. As these were isomers of methyl propanoate, they also could be awarded two marks.

Weaker responses had structures with pentavalent C atoms, trivalent O atoms and divalent H atoms.

(iv) 'Catalyst' was often seen. Many different temperatures and pressures were also given.

CHEMISTRY

Paper 0620/43
Theory (Extended)

Key messages

- Candidates are advised that if a question either asks for observations or asks for a description of what would be seen, they should give as appropriate:
  - colour changes (requiring initial and final colours)
  - effervescence
  - solids dissolving or disappearing
  - precipitates forming (with their colours); this only applies if two solutions are mixed
  - heat changes
  - smells and colours of gases.

  It is unnecessary to give:
  - names of products
  - theoretical explanations
  - details of types of reactions.

  It is unnecessary to describe a test for a gas unless the question specifically asks for one.

- If candidates wish to make corrections to their answers these should be done clearly.

General comments

Occasionally, in the dot-and-cross diagram in **Question 4(b)(ii)** it was not clear what was rubbed out and what was not.

It was apparent that many candidates were not prepared for questions on Organic Chemistry. This was evident mainly in answers to **Question 7(c)**.

Ionic equations, including half-equations, are an area that needs considerable improvement.

Comments on specific questions

Question 1

(a) This question was answered very well. The masses were less well known than the charges.

(b) This question was answered very well. Many candidates gained full credit. The symbol for fluorine was sometimes given as F*l*.

Question 2

(a) This question was answered very well. Both **F** and **I** were occasionally given

(b) This question was answered very well. **F** was occasionally given.

(c) This question was answered very well. All three substances were usually correct. **D** was sometimes given, presumably because it was a non-conductor of electricity.

(d) This question was answered very well. Those who correctly identified **G** as a metal did not always give good electrical conductivity *when solid* as the correct reason. Substances other than metals are electrical conductors when liquid. High melting point and high boiling point applies to macromolecules as well as metals, which is why good electrical conductivity when solid is the reason that was expected.

(e) This question was answered well. Macromolecules have high melting points and high boiling points. They are non-conductors of electricity in both solid and liquid states. **H** was sometimes given by those who focused on non-conduction but ignored melting point and boiling point. Some responses stated poor conductor instead of non-conductor.

(f) This was the least well answered of **(d)** to **(f)**. **G** was a frequent answer. Those who correctly identified **E** as an ionic solid did not always give good electrical conductivity *when liquid but not when solid* as the correct reason. Metals conduct when both liquid and solid, which is why the distinction is important.

Question 3

(a) This question was answered well. Hematite was occasionally seen as the most common incorrect answer. Alumina was seen occasionally.

(b) (i) Candidates found this challenging. The following statements were commonly seen in addition to the correct answers:

- decrease of the melting point of aluminium
- decrease of the melting point of aluminium oxide was very common
- decrease in the boiling point (the electrolyte remains liquid throughout electrolysis)
- cryolite is a catalyst or cryolite speeds up electrolysis.

Reduction of the operating temperature was more commonly given than increase in conductivity.

(ii) Candidates found this challenging. Common errors included:

- Al and O_2 were often seen on the *left*-hand side of ionic half-equations
- Al^{3+} and O^{2-} were often seen on the *right*-hand side of ionic half-equations
- O was often seen instead of O_2
- many candidates did not give the correct charge on the aluminium ion
- $Al^{3+} + 3e^- \rightarrow$ **3**Al was commonly seen at the negative electrode
- in the anode half-equation the number of electrons was often unbalanced
- a half-equation for the discharge of OH^- was occasionally seen.

The negative electrode half-equation was correct more often than the positive electrode half-equation.

(iii) Many answers stated that the anode corroded, without further qualification. Those who knew that the carbon anode reacted with oxygen did not always give the product. Carbon monoxide was seen occasionally.

(c) (i) Candidates performed poorly on this question. Many attempted a symbol equation instead of an ionic equation. Many started with Mg^{2+} on the left-hand side.

Some gave $Mg^{2+} + SO_4^{2-} \rightarrow MgSO_4$, with or without state symbols, as though the reaction was a precipitation reaction.

(ii) Many of the answers ignored the instruction to give observations.

The following statements were commonly seen, none of which gained credit:
- magnesium dissolves
- brown *precipitate*
- brown metal
- copper forms
- blue colour fades.

(iii) Candidates found this challenging. Most of the answers were in terms of reactivity of aluminium, copper and magnesium. Some referred to the absence of nitrate ions. The existence of an unreactive layer of aluminium oxide was rarely mentioned.

(d) This question was answered quite well. Al_2 and Fe_2 were seen occasionally, as were ions with various charges.

Question 4

(a) Candidates found this challenging. The question informed candidates that a molecule of phosphorus contained four atoms; answers without four, including P_2 and P_3, were common. Positive and negative ions were often seen, mainly P^{3+} and P^{3-}.

(b) (i) This was answered reasonably well. The most common error was to see formulae of phosphorus and chlorine given as atoms or ions instead of molecules.

(ii) This was answered well. Most candidates gained full credit. Better performing candidates tended to draw electrons in pairs. Non-bonding electrons on the chlorine atoms were sometimes missing.

If candidates wish to make corrections to their answers these should be done clearly. Occasionally, it was not clear what was rubbed out and what was not.

(c) (i) This was answered well. Many good answers gained full credit. The most common errors were subtraction the wrong way around i.e. 1630 – 1221 = 409 or 1221 – 1630 = 409 (missing out the negative sign).

(ii) Responses such as, ‘reaction is exothermic because heat energy is given out to the surroundings’, lacked sufficient explanation. Stronger responses explained that the energy evolved was greater than the energy absorbed.

The most common errors were to refer to ‘energy needed to form bonds’ or ‘energy given out when bonds are broken’; both statements are wrong.

(d) Candidates should be familiar with questions that ask for an explanation on the position of equilibrium following a change in conditions. Better responses stated, ‘there are more molecules on the left-hand side than on the right-hand side of the equation. Therefore, the equilibrium shifts to the right-hand side when pressure is increased.’

The following statements were common and did not achieve credit:
- the *reaction* with the most molecules (should be the *side* with the most molecules)
- forward reaction occurs (different to forward reaction is favoured or equilibrium shifts forward)
- greater yield (without saying greater yield of which substance)
- more *particles* on the left-hand side (should be more *molecules*).

Several candidates stated there was the same number of moles or molecules on both sides. There were references to exothermic or endothermic reactions as well as reaction rates.

(e) Candidates performed well on this question. Most candidates had a 3 and a 2 on the right-hand side of the equation. The 6 on the left-hand side was less common. It was common to see 3 instead of 6.

(f) (i) Candidates found this challenging. The ‘ions’ were often uncharged. NH_3^+ and NH_4^- were common.

(ii) Candidates found this challenging. There were no common incorrect answers.

(g) This was answered quite well. There were no common incorrect answers.

(h) (i) This was answered well. Answers were occasionally numbers instead of formulae. The proton number of phosphorus was occasionally used instead of its relative atomic mass.

(ii) This was answered less well. Answers were occasionally numbers instead of formulae. $2PH_2$ was sometimes seen.

Question 5

This was answered well. All full credit was often awarded. An occasional error was to use a mole ratio of 2:1 instead of 1:2.

Question 6

(a) This was answered quite well. Irrelevant comments on pH, concentration, the effect on indicators and reactions of acids were seen occasionally.

(b) Candidates found this challenging. 25.0 cm^3 was seen occasionally. The mole ratios in both experiments were different. This means that if the same volumes were mixed in both experiments the same salt would be produced. 12.5 cm^3 was the most common answer.

(c) (i) This was answered quite well. There was a variety of incorrect colours as well as references to other observations.

(ii) Candidates found this very difficult. As in **Question 3(c)(ii)**, many of the answers ignored the instruction to give observations. Copper(II) oxide dissolves and 'it' turns blue were two common examples. Bubbles were regularly referred to despite the fact that no gas is evolved in the reaction between an acid and a metal oxide. A blue solid was mentioned occasionally.

(d) (i) Candidates performed reasonably well on this question. There were no common wrong answers.

(ii) As with other ionic equations, candidates found this very challenging.

In an ionic equation for a precipitation reaction, the two ions in aqueous solution that react to form the precipitate are on the left-hand side. The solid precipitate is on the right-hand side. This was known by only a small number of candidates.

$SO_4^{2-} \rightarrow SO_4 + 2e^-$ and other attempts at ionic half-equations were seen occasionally. Chlorine was regularly seen as a product.

Question 7

(a) This was answered reasonably well. Double bond (without specifying carbon to carbon), alkane and C_nH_{2n} were the most common errors.

(b) (i) This was answered reasonably well. Six was the most common incorrect answer. Two was seen occasionally.

(ii) Those who knew the structure of the monomer often omitted to show all of the atoms and all of the bonds in the $–CH_3$ groups.

All straight chain alkenes with more than 3 carbon atoms must have a number in their name because the double bond can be in different positions. Thus, the alkene in this case is but-2-ene (as opposed to butene) in order to distinguish it from but-1-ene. A common name was 1,2-dimethylethene from candidates who decided that the $–CH_3$ groups were branches and not part of the longest chain.

(iii) Candidates found this very challenging and seemed to be unaware of the term *empirical formula* unless it stemmed from a calculation. Empirical formulae are the representation of the *smallest* whole number ratio of atoms of each element in one molecule. All alkenes e.g. C_2H_4, C_3H_6 and C_4H_8, have an empirical formula of CH_2. All addition polymers made from alkene monomers are formed without any removal of atoms, therefore the empirical formula of all such addition polymers is CH_2. A variety of incorrect answers was seen.

(c) There were some excellent answers to this question. Some candidates seemed unfamiliar with any of the practical techniques or the Chemistry involved. Some candidates used experimental detail and conditions from fermentation of carbohydrates or hydration of ethene.

Cracking, decomposition, hydration and polymerisation were the most common errors in describing how **X** was broken down. These processes were given as well as, or instead of, hydrolysis. It was rare to see candidates refer to both acids and enzymes.

Yeast was often given as a substance used to break down **X**.

Fractional distillation was often given as well as, or instead of, chromatography as a means of separating the monomers.

Ninhydrin is used as a locating agent for amino acids as opposed to simple sugars. Bromine water was often chosen as a substance used to detect the monomers as if they were alkenes as opposed to simple sugars.

R_f was commonly known as a method of identification.

(d)(i) This was answered quite well. *Terylene* and proteins were seen occasionally.

(ii) This was answered quite well. The most common incorrect answers were hydrochloric acid or hydrogen chloride.

CHEMISTRY

Paper 0620/51
Practical

Key messages

- Burette readings should be given to at least one decimal place and this includes '0.0' for a zero reading.
- Candidates should have practical experience of doing a flame test.
- Candidates should go through their plans when answering **Question 3** before writing their response, as often extra sentences were inserted to cover missing points realised later.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit can not be awarded.
- Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.

General comments

The majority of candidates successfully completed all questions and there was no evidence that candidates were short of time. The complete range of marks was seen.

Candidates performed well on **Question 3** and many candidates seemed familiar with this experiment.

Examiners use Supervisors' results to check comparability in **Questions 1** and **2**. The results obtained by some Supervisors and candidates in **Question 1** suggested that some centres did not use the materials specified in the Confidential Instructions.

Comments on specific questions

Question 1

(a) Almost all candidates successfully completed the tables of results.

Common errors were:
- not recording all readings to one decimal place
- recording initial burette readings incorrectly at values other than 0.0 cm^3
- recording final burette readings incorrectly as values less than initial burette readings or values greater than 50 cm^3.

(b) Many candidates incorrectly described the initial colour as orange instead of yellow. Some candidates described colours not shown by methyl orange.

(c) Candidates found this challenging as many did not understand that universal indicator is not suitable for titrations as there is no clear, quick, colour change at the end point. Answers involving the multiple and gradual colour changes were also accepted. Some candidates thought that universal indicator would not change colour or could only give the pH value of the solution.

(d) (i) Most candidates could correctly identify the solutions that needed the smallest and largest volumes of hydrochloric acid to change colour.

(ii) Most candidates could correctly work out the simplest whole number ratio. A common error was to give the ratio as Experiment 2 : Experiment 1.

(iii) Candidates found putting the solutions into the correct order of concentration difficult. Many reversed the order thinking that a smaller volume of acid meant that the alkali was more concentrated rather than less concentrated.

(e) Most candidates did not realise that changing the temperature will not affect the volumes used in a titration as it does not change the concentrations. Many candidates referred to the idea that an increase in temperature would make the reaction faster; this is irrelevant in this neutralisation reaction.

(f) Nearly all candidates knew that checking the reliability would involve repeating the experiments. However, taking an average alone does not check the *reliability*. The results must be first compared and any anomalous results discarded. Taking the average or mean improves the *accuracy*.

The candidates who wanted to repeat the experiments with different volumes or concentrations of solutions showed a lack of understanding, as did those who wanted to repeat them without using an indicator.

(g) This question provided a very wide range of responses. Better performing candidates found a reagent or method that would distinguish between three solutions of sodium hydroxide of different concentrations. The expected responses involved the evolution of a gas, such as ammonia from the reaction with an ammonium salt or hydrogen from a metal such as aluminium. Measuring the temperature change in the reaction with dilute hydrochloric acid was also a popular method. Candidates came up with novel ideas such as evaporation and measuring the mass of the residue, sometimes preceded by neutralisation or even measuring the conductivity of the solutions.

Many candidates chose a method that would not work, such as using magnesium in the incorrect belief that hydrogen would be given off. These responses were still given credit for the method they would use to measure the rate, usually the collection of the gas or time for the solid to dissolve. Unfortunately, some methods gave neither a correct method nor measurements that could be made.

A significant number ignored the instruction that the method should not involve an indicator.

Question 2

(a) Some candidates correctly recorded a lilac coloured flame. References to the colour of the solid were common and scored no credit. A significant number of candidates were not familiar with doing a flame test.

(b) The majority of candidates correctly described the colour of the aqueous solution of solid **U**.

(c) (i) The majority of candidates reported the formation of a green precipitate. A number of candidates missed the fact that a precipitate formed as the aqueous sodium hydroxide was not added drop wise. References to cloudy, solid formation were ignored. Incorrect observations such as formation of a white precipitate were penalised.

(ii) The majority of candidates correctly noted the formation of a green solution as the precipitate dissolved.

(d) (i) Many candidates reported the formation of a green precipitate rather than a grey-green precipitate. Candidates should make use of the notes at the end of the question paper.

(ii) The precipitate remaining was often described; some candidates incorrectly described the solubility of the precipitate to form a solution.

(e) Candidates who followed the instruction of leaving the product to stand for 5 minutes were able to state that a white precipitate was formed. Many candidates did not wait for the precipitate to settle and reported blue or grey precipitates as the white was masked by the colour of the solution.

(f) Most candidates identified the presence of chromium(III) ions; a number stated that iron(II) or just iron ions were present. Most managed to identify the sulfate ion based on their observation in **(e)**. A number identified the presence of chloride or bromide ions despite no test for a halide ion being performed.

(g) Most candidates correctly stated that the liquid was colourless. References to a clear or transparent liquid scored no credit.

(h) Many candidates successfully reported that the liquid caught fire.

(i) Credit was awarded for recording the formation of a purple/pink colouration; a significant number of candidates stated that the iodine did not dissolve. Good answers referred to some of the iodine crystal dissolving but a little remained.

(j) Many candidates drew one correct conclusion about liquid **V**. There were some references to named ions, e.g. chloride and sulfate, despite no tests having been carried out.

Question 3

Good answers mentioned:
- use of a known volume of water
- initial temperature of the water before adding the solid
- addition of a measured mass of potassium nitrate
- final temperature of solution/temperature at fixed intervals
- repeat with known mass of ammonium chloride and same volume of water
- conclusion, e.g. greater temperature change/decrease is larger energy change or calculate energy change per gram.

The most common errors were:
- to measure the initial temperature of the solid, rather than of the water
- failure to stir/mix the mixture to aid dissolving
- reference to fixed volumes of the two salts instead of masses
- confusion that an endothermic change resulted in an increase in temperature rather than a decrease.

A minority of candidates showed a lack of knowledge and understanding by using a Bunsen burner to heat the solutions.

CHEMISTRY

Paper 0620/52
Practical

Key messages

- Candidates should have practical experience of doing a flame test.
- Candidates should go through their plans when answering **Question 3** before writing their response, as extra sentences were often inserted to cover missing points realised later.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit can not be awarded.
- Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.

General comments

The majority of candidates successfully completed all questions and there was no evidence that candidates were short of time. The complete range of marks was seen.

Examiners use Supervisors' results to check comparability in **Questions 1** and **2**. The results obtained by some Supervisors and candidates in **Question 1** suggested that some centres did not use the materials specified in the Confidential Instructions.

Comments on specific questions

Question 1

(a) and **(b)**
All candidates completed the tables of results. Expected results were obtained by the majority of candidates, with temperatures rising in Experiment 1 and decreasing in Experiment 2 and generally agreeing well with those obtained by the Supervisors. A significant number of centres obtained results with the temperatures increasing in Experiment 2.

(c) Most candidates plotted all points correctly; choosing an appropriate scale on the vertical axis of the graph caused some candidates problems. A common error was to start the temperature axis at 0 °C, meaning that the plotted points covered less than half of the *y*-axis. Most curves were good attempts and best-fit straight lines drawn with a ruler scored credit when appropriate. Some candidates joined the points dot to dot with a ruler.

(d) (i) Many answers were given without following the instruction to show clearly on the grid how they were deduced.

(ii) Many candidates did not clearly extrapolate their graph and did not show where they had read their answer from the grid. Some candidates misread their scale on the *y*-axis.

(e) Generally correctly answered with an explanation given in terms of the temperature change.

(f) The suggested improvements were often irrelevant to this experiment, such as starting at a common temperature, using the same mass of solid N and O or using a stirring rod instead of a stirring thermometer. Vague answers discussed using a stop-watch instead of a stop-clock or dipping the thermometer in a constant position in the conical flask, or using a different sized flask.

Better performing candidates repeated the experiments and found the average/mean of the readings or used insulation to reduce heat losses. Using a burette or a pipette instead of a measuring cylinder to measure the volume of water would also be more accurate.

(g) Better responses explained that the temperature rise would be greater or faster as there was a lower volume of water present. Many candidates thought that the temperature rise would be lower or that the solids would not be able to dissolve.

Question 2

Solid **P** was copper(II) nitrate.

Solid **Q** was potassium bromide.

tests on solid P

(a) Most candidates correctly stated that the flame colour was green-blue or blue. References to green only or yellow were not accepted.

(b) (i) The majority of candidates reported the formation of a blue precipitate.

(ii) The blue precipitate was insoluble in excess aqueous sodium hydroxide.

(c)(i)(ii) The majority of candidates reported the formation of a blue precipitate, which dissolved in excess aqueous ammonia to form a deep blue solution. Some confused answers referred to the blue precipitate dissolving to form a deep blue precipitate, while other missed the initial formation of the blue precipitate.

(d) Better performing candidates recorded three different observations. References to the litmus turning blue and a pungent smell were most common. Stating that ammonia was present did not score credit, as this statement is not an observation.

Effervescence was often missed and the formation of a black solid was rarely mentioned.

The formation of a white precipitate was often described. References to cloudy or solid formation were ignored.

(e) Most candidates identified the presence of copper ions; a number stated that sulfate ions were present despite a positive test for nitrate ions in **(d)**. A number concluded that bromide ions were present.

tests on solid Q

(f) Many candidates recorded a red or yellow flame colouration, despite a lilac flame being the expected result. Some candidates had clearly not experienced a flame test and discussed lighted and glowing splints.

(g) The formation of a cream precipitate was given by some candidates. A significant number omitted precipitate and merely wrote a colour. Many other candidates incorrectly described the formation of a white or yellow precipitate. This showed a lack of practical expertise and experience when carrying out the halide test.

(h) Many candidates correctly identified both ions present in solid **Q**. There was some confusion between potassium and sodium. Other candidates confused bromine and bromide.

Question 3

The complete range of marks was seen in this planning question.

Some candidates did not read the information in the stem of the question and spent some time either experimenting with the individual substances in the mixture or preparing the mixture, even though the mixture was provided.

The information in the table showed how the substances reacted with nitric acid. Despite this, a number of candidates used water or other acids to separate the mixture.

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

Better performing candidates included the following in their plans:

- adding dilute nitric acid to the mixture
- in a suitable named container – beaker, flask or test-tube
- stir or shake the mixture
- until reaction stops/excess acid
- filter
- wash residue/polystyrene beads with water
- dry residue/polystyrene beads.

A significant number of candidates showed a lack of knowledge and understanding and described how the polystyrene beads could be obtained by crystallisation of the polystyrene beads from a saturated solution of the filtrate.

CHEMISTRY

Paper 0620/53
Practical

Key messages

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(iii) Candidates found putting the solutions into the correct order of concentration difficult. Many reversed the order thinking that a smaller volume of acid meant that the alkali was more concentrated rather than less concentrated.

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The candidates who wanted to repeat the experiments with different volumes or concentrations of solutions showed a lack of understanding, as did those who wanted to repeat them without using an indicator.

(g) This question provided a very wide range of responses. Better performing candidates found a reagent or method that would distinguish between three solutions of sodium hydroxide of different concentrations. The expected responses involved the evolution of a gas, such as ammonia from the reaction with an ammonium salt or hydrogen from a metal such as aluminium. Measuring the temperature change in the reaction with dilute hydrochloric acid was also a popular method. Candidates came up with novel ideas such as evaporation and measuring the mass of the residue, sometimes preceded by neutralisation or even measuring the conductivity of the solutions.

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A significant number ignored the instruction that the method should not involve an indicator.

Question 2

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(ii) The precipitate remaining was often described; some candidates incorrectly described the solubility of the precipitate to form a solution.

(e) Candidates who followed the instruction of leaving the product to stand for 5 minutes were able to state that a white precipitate was formed. Many candidates did not wait for the precipitate to settle and reported blue or grey precipitates as the white was masked by the colour of the solution.

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(g) Most candidates correctly stated that the liquid was colourless. References to a clear or transparent liquid scored no credit.

(h) Many candidates successfully reported that the liquid caught fire.

(i) Credit was awarded for recording the formation of a purple/pink colouration; a significant number of candidates stated that the iodine did not dissolve. Good answers referred to some of the iodine crystal dissolving but a little remained.

(j) Many candidates drew one correct conclusion about liquid **V**. There were some references to named ions, e.g. chloride and sulfate, despite no tests having been carried out.

Question 3

Good answers mentioned:
- use of a known volume of water
- initial temperature of the water before adding the solid
- addition of a measured mass of potassium nitrate
- final temperature of solution/temperature at fixed intervals
- repeat with known mass of ammonium chloride and same volume of water
- conclusion, e.g. greater temperature change/decrease is larger energy change or calculate energy change per gram.

The most common errors were:
- to measure the initial temperature of the solid, rather than of the water
- failure to stir/mix the mixture to aid dissolving
- reference to fixed volumes of the two salts instead of masses
- confusion that an endothermic change resulted in an increase in temperature rather than a decrease.

A minority of candidates showed a lack of knowledge and understanding by using a Bunsen burner to heat the solutions.

CHEMISTRY

Paper 0620/61
Alternative to Practical

Key messages

- Candidates should use a sharp pencil for clearly 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 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.
- Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.
- Candidates should go through their plans when answering **Question 4** before writing their response, as extra sentences were often inserted to cover missing points realised later.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit cannot be awarded.

General comments

The majority of candidates attempted all of the questions. A significant minority left many questions unattempted. Some candidates were clearly not well prepared for this examination and showed a lack of experience with knowledge of practical procedures. The paper discriminated successfully between candidates of different abilities but was accessible to all. Candidates found **Question 4** to be the most demanding.

Comments on specific questions

Question 1

(a) Apart from a few ice baths and flasks, the beaker was usually identified correctly.

(b) Reference to condensation gained credit. Most candidates thought the water came from the melted ice or ethanol vapour, which showed a lack of understanding.

(c) Very few candidates knew a chemical test for water. Boiling point and universal indicator were common answers.

(d) The idea of drawing the gases through the apparatus was not well understood.

(e) Limewater turning milky was often realised; vague comments about bubbles and effervescence were prevalent.

Question 2

(a) The volumes of gas in the table of results were completed correctly from the measuring cylinder diagrams by the majority of the candidates. The reading at 0 seconds was sometimes recorded as 12 instead of 0.

(b) Most candidates plotted the points on the grid correctly; some omitted the origin point. Some graphs were not smooth lines as they included the anomalous point. The use of a ruler to join the points dot to dot was penalised.

(c) (i) A significant minority circled the wrong point.

(ii) Most candidates deduced the time taken to collect 40 cm^3 of gas; many did not clearly show how they arrived at the answer.

(d) Most correct responses referred to the advantage of using a gas syringe instead of a measuring cylinder as an improvement. Few candidates referred specifically to the use of a 250 cm^3 measuring cylinder to measure a maximum volume of 77 cm^3 of gas as being the source of error and thus replacing it with a 100 cm^3 measuring cylinder.

(e)(i)(ii) This was well answered by the majority of the candidates.

(f) Numerous answers referred to the magnesium carbonate being all used up despite having been informed that it was in excess. Credit was given for understanding that the volume of gas obtained was less than expected. Correct explanations for the lower volume were infrequent – the possibility of some gas escaping or dissolving in water was realised by few candidates.

(g) Repeating the experiment at a lower temperature would result in a slower reaction and many sketches showed this with a less steep curve than the original. The use of excess solid would result in the same total volume of gas and therefore the sketch curve would be at the same level. Many sketch curves did not end at the same level.

Question 3

(a)(i)(ii) Many responses showed that candidates had experienced this test and therefore observations were correct. A white precipitate, which was soluble when excess aqueous sodium hydroxide was added, was expected.

(b)(i)(ii) This was generally well answered, with the formation of a white precipitate which dissolved in excess aqueous ammonia.

(c) Some candidates realised that ammonia was produced but did not give a test and the expected observations. Credit was awarded for litmus turning blue and reference to a pungent smell.

(d) Many candidates were familiar with the flame test and deduced that solid B was a lithium compound. Only a minority correctly identified lithium iodide; sulfate and chloride were common.

Question 4

Good answers included the following points:
- known volume of ethanol
- known mass of iodine
- stir/shake
- filter
- dry and weigh undissolved iodine
- repeat with hexane
- conclusion.

Some candidates were ill prepared for this planning question and did not attempt it. A range of marks was seen. A large number of responses lacked detail, e.g. ‘add iodine to the solvents’, with no mention of quantities or the idea of a fair test. A large number of candidates thought that iodine was a liquid and used a volume of it. A significant number of responses referred to the use of a chronometer/stop-watch which showed confusion between how fast the iodine dissolves and how much iodine dissolves, which was required in the question.

Methods involving adding solvent to a known mass of iodine until it dissolved completely were awarded marks similarly.

CHEMISTRY

Paper 0620/62
Alternative to Practical

Key messages

- Candidates should use a sharp pencil for clearly 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 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.

- Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.

- Candidates should go through their plans when answering **Question 4** before writing their response, as extra sentences were often inserted to cover missing points realised later.

- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit cannot be awarded.

General comments

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

Some candidates showed evidence of having little practical laboratory experience. This was particularly evident in **Question 1**.

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

Comments on specific questions

Question 1

(a) A number of candidates named pipette and burette the wrong way round. A significant number of candidates incorrectly named the pipette as a dropper or teat pipette.

(b) Most candidates named methyl orange or phenolphthalein. Universal indicator was widely quoted and this is not a suitable indicator for a titration. Colour changes were often the wrong way around. Orange to red was a common incorrect colour change for methyl orange.

(c) Most candidates stated ‘the volume of sulfuric acid used’. Only a minority realised that the initial and final readings of the acid in the burette should be recorded. A minority of candidates showed a lack of understanding referring to the ‘drops of acid’.

(d) Good answers showed an understanding that there would be no effect on the titration values as the amount of sodium hydroxide added to the flask would still be the same. Common wrong answers were concerned with the dilution effect of the water.

Question 2

(a) and (b)
Almost all candidates correctly completed the tables of results from the thermometer diagrams.

(c) Most candidates plotted all points correctly. Most curves were good attempts and dot to dot straight lines drawn with a ruler were rare. Some candidates drew a best-fit straight-line when a smooth curve was the obvious choice. The graphs were often not labelled.

(d) (i) Many candidates clearly indicated on their graph and showed clearly where they had read their answer from the grid at 18 °C. Some candidates misread their scale on the *y*-axis.

(ii) Generally, this was correctly answered. Some candidates did not extrapolate the graph and others misread the scale on the *y*-axis.

(e) Experiment 2 was identified as an endothermic change as the temperature decreased. A minority gave no explanation or thought it was exothermic.

(f) Often the suggested improvements were irrelevant to this experiment, such as starting at a common temperature; using the same mass of solid N and O or using a stirring rod instead of a stirring thermometer.

Better responses repeated the experiments and found the average/mean of the readings, or used insulation to reduce heat losses. Using a burette or a pipette instead of a measuring cylinder to measure the volume of water would also be more accurate.

Question 3

(a) The majority of candidates correctly stated that the flame colouration would be blue-green or blue. Incorrect references to green and yellow were common. Some candidates thought a flame test was a test for hydrogen or oxygen.

(b) The majority of candidates reported the formation of a blue precipitate. Some confused answers referred to the precipitate dissolving.

(c) (i)(ii) The majority of candidates reported the formation of a blue precipitate, which dissolved in excess aqueous ammonia to form a deep blue solution. Some confused answers referred to the blue precipitate dissolving to form a deep blue precipitate, while others missed the initial formation of the blue precipitate.

(d) This was well answered. The use of litmus paper turning blue was frequently given, as was a good description of a pungent smell. The formation of a white precipitate was often wrongly described.

(e) Many candidates correctly identified the presence of potassium in solid **Q** from the flame test. A number did not recognise the presence of bromide ions from the result of the halide test.

Question 4

Some candidates did not read the information in the stem of the question and spent some time either experimenting with the individual substances in the mixture or preparing the mixture, even though the mixture was provided.

The information in the table showed how the substances reacted with nitric acid. Despite this, a number of candidates used water or other acids to separate the mixture.

A minority of candidates used the wrong method, such as fractional distillation or heating the mixture. These methods showed a lack of knowledge and understanding. A significant number of incorrectly described how the polystyrene beads could be obtained by crystallisation of the polystyrene beads from a saturated solution of the filtrate.

Better responses:
- added dilute nitric acid to the mixture
- used a suitable named container – beaker, flask or test-tube
- stirred or shook the mixture
- and continued until reaction stops/excess acid
- filtered
- washed residue/polystyrene beads with water
- dried residue/polystyrene beads.

CHEMISTRY

Paper 0620/63
Alternative to Practical

Key messages

- Observations are those which you can see. For example, 'fizzing' is an observation, whereas 'a gas was given off' is not. Smells, such as the pungent smell of ammonia and the bleach or swimming pool smell of chlorine, are acceptable as observations.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit cannot be awarded.
- Burette readings should be given to at least one decimal place and this includes '0.0' for a zero reading.

General comments

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

No question proved to be more demanding than the others, all discriminated equally well.

The vast majority of candidates were able to complete tables of results from readings on diagrams in **Question 2**.

Question 4 was a planning task based on two salts, which dissolved endothermically. Nearly all candidates correctly added the same mass of each salt to two samples of water of the same volume, measuring the initial and final/lowest temperature.

Comments on specific questions

Question 1

(a) Most candidates could identify the (inverted) measuring cylinder; a number thought that it was a gas jar, despite the graduations.

(b) The majority of candidates knew that time had to be measured. The volume of the gas/oxygen was less well known, with many measuring the volume of water or hydrogen peroxide. Some did not mention 'volume' in their answers.

(c) (i) Most candidates could explain why the rate of the reaction decreased. A large number incorrectly thought that it was because the catalyst (manganese(IV) oxide) was being used up.

(ii) Most candidates realised that the hydrogen peroxide (or reactant) had been used up. The idea that the reaction had finished was also accepted.

(d) (i) Nearly all responses stated that filtration was used to separate the catalyst at the end of the reaction. Evaporation was also acceptable in this case, as the only products were water and a gas.

(ii) This was a more challenging question, but it was very well answered. Most methods of showing that the catalyst was unchanged involved drying it and reweighing it; although, a number separated it and then re-used it in a repeat of the original experiment.

Question 2

(a) Most candidates read the burettes correctly to work out the volume used. The most common error was to write the zero volume as 0 rather than 0.0. Readings should be recorded in a consistent manner in terms of decimal places. Candidates should know that the final burette reading will always be higher than the initial reading. A few did get them all the wrong way around, whilst others subtracted them all from 50.0.

(b) The colour change of methyl orange was fairly well known; a significant number did get it the wrong way around.

(c) Many candidates found this challenging and did not understand that universal indicator is not suitable for titrations as there is no clear, quick, colour change at the end point. Responses involving the multiple and gradual colour changes were also accepted.

(d) (i) Most candidates could correctly identify the solutions that needed the smallest and largest volumes of hydrochloric acid to change colour.

(ii) Most candidates could correctly work out the simplest whole number ratio.

(iii) Putting the solutions into the correct order of concentration was difficult for many candidates and some reversed the order completely.

(e) Most candidates did not realise that changing the temperature will not affect the volumes used in a titration as it does not change the concentrations.

(f) The majority of candidates knew that checking the reliability would involve repeating the experiments. However, taking an average alone does not check the *reliability*. The results must be first compared and any anomalous results discarded. Taking the average or mean improves the *accuracy*.

(g) This question provided a very wide range of responses. Better responses gave a reagent or method that would distinguish between three solutions of sodium hydroxide of different concentrations. The expected responses involved the evolution of a gas, such as ammonia from the reaction with an ammonium salt or hydrogen from a metal such as aluminium. Measuring the temperature change in the reaction with dilute hydrochloric acid was also a popular method However, candidates came up with novel ideas such as evaporation and measuring the mass of the residue, sometimes preceded by neutralisation or even measuring the conductivity of the solutions.

Many candidates chose a method that would not work, such as using magnesium in the incorrect belief that hydrogen would be given off. These responses were still given credit for the method they would use to measure the rate, usually the collection of the gas or time for the solid to dissolve. Unfortunately, some methods gave neither a correct method nor measurements that could be made.

Question 3

(a) Candidates appeared to be less familiar with the chemistry of chromium(III) cations. Most candidates realised that chromium(III) compounds were green, although there was a variety of incorrect colours. A significant minority referred to the solution as a solid, crystals or precipitate.

(b) (i) Some responses correctly stated the formation of a green precipitate. The colour of the precipitate was needed for full credit.

(ii) Most candidates who gained credit in **(i)** went on to state that the green precipitate dissolved in excess.

(c) The grey-green precipitate with ammonia was less well known. Many candidates appeared to think that this was a continuation of the sodium hydroxide test in **(b)**, missing the reference to the second portion.

(d) The test for ammonia was very well known. A few candidates were not familiar with the test for nitrate.

(e) This was a less familiar compound for the qualitative analysis question. Despite the wide range of acceptable answers, a minority gained credit here. The most popular incorrect response was that it was a copper compound, probably because of the blue flame.

Question 4

Candidates performed well on this planning task. The majority knew that they needed to use the same mass of both salts, dissolving them in equal volumes of water and measuring the initial and final/lowest temperatures. Common errors included measuring the initial temperature of the solid or the solution after adding the solid, using a volume of the salts and measuring the highest temperature. A minority of candidates showed a lack of knowledge and understanding by using a Bunsen burner to heat the solutions.