CHEMISTRY (US)

Paper 0439/13
Multiple Choice

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

Candidates performed quite well on this paper. Questions **1**, **14**, **19**, **27** and **31** proved to be the most straightforward.

Questions **4**, **13**, **17**, **21**, **25**, **28**, **37**, **38** and **40** were the most difficult for candidates.

The following were common incorrect responses to the questions listed:

Question 4

Response **C**. Candidates assumed that the question was about isotopes although it was stated that the atoms in question had *different* chemical properties.

Question 13

Response **A**. Candidates knew the colour change but did not account for the information regarding the temperature change.

Question 17

Responses **A**, **C** and **D**. All responses had a significant number of candidates opting for them, indicating that the topic was generally not well understood.

Question 21

Response **A**. Candidates found this question difficult as there was more than one piece of information to take into account. Candidates choosing response **A** identified a Group I metal but did not take into account the displacement reaction.

Question 25

Response **C**. Candidates did not realise that lime is added in the manufacture of steel to remove acidic impurities.

Question 28

Response **D**. Candidates chose two processes which use oxygen without taking into account whether or not they are useful. They also did not realise that oxygen is used in steel manufacture.

Question 37

Response **C**. Candidates chose an answer which did apply to all of the compounds but did not sufficiently explain their chemical similarity.

Question 38

Response **B**. Candidates thought that the C=O double bond decolourises bromine water in the same way as the C=C double bond in alkenes.

Question 40

Response **B**. Candidates did not realise that the reaction of ethene with steam is an addition reaction.

CHEMISTRY (US)

Paper 0439/21

Core Theory

Key Messages

- It is important that candidates read questions carefully in order to understand what is exactly being asked.
- Many candidates would benefit from more practice in answering questions about the properties of Group I elements and the conversion of iron into steel.
- Greater exactitude is required in explaining and using particular chemical terms, such as isotopes and electrolysis.
- Interpretation of data from tables and completing balanced equations were generally done well.

General Comments

Many candidates showed a good knowledge of core Chemistry. Nearly all candidates were entered at the appropriate level. The standard of English was generally good. Some of the questions were left unanswered by a minority of candidates. This was especially apparent in **Questions 2(d)** (purification of ethanol), **5(b)(i)** (calculation of relative molecular mass) and **6(a)(iv)** (conversion of iron into steel).

Some questions were misread or the rubric was misinterpreted by a minority of candidates. For example, in **Question 2(d)** some candidates wrote about chromatography, in **4(c)(i)** most gave the electronic structure of a hydrogen atom rather than a hydrogen molecule, whilst in **6(b)** some did not state the differences of the reactions of lithium and potassium with water.

Many candidates were unable to distinguish between atoms, molecules and ions and between compounds and elements. Chemical definitions such as those for isotopes and electrolysis were recalled by few candidates.

Some candidates would benefit from more practice in recalling simple chemical tests e.g. bromine water test for unsaturation and limewater test for carbon dioxide.

Many candidates were able to calculate relative atomic masses and identify functional groups.

Questions involving general chemistry including electrolysis and rates of reaction were well tackled by many candidates.

Comments on specific questions

Question 1

Most candidates identified at least three of the structures correctly in part **(a)**. Fewer completed the equation correctly in part **(b)** or knew the limewater test for carbon dioxide in part **(c)**.

(a) In part **(i)** many candidates correctly identified **D** as being an element. The commonest error was to suggest **C** (ethane). In part **(ii)** many could not distinguish a saturated from an unsaturated hydrocarbon; the commonest incorrect answer being **E** (ethene). In part **(iv)**, many candidates chose the ionic giant structures rather than the covalent structure, **D**. In part **(vi)** some candidates did not check the atomic masses of Ca and Zn and hence chose the incorrect giant structures. Others appeared not to understand the word ‘ion’ and chose covalent structures. There were no consistently common errors in parts **(iii)** and **(v)**.

(b) Many candidates recognised **B** as being calcium carbonate. Fewer identified the product of the thermal decomposition. The commonest errors were to suggest compounds containing atoms which were not on the left hand side of the equation e.g. hydrogen, water, compounds of metals other than calcium. Oxygen or carbon monoxide were other common errors.

(c) Some candidates knew the test for carbon dioxide. Others incorrectly suggested testing with litmus or sodium hydroxide.

Question 2

Nearly all candidates recognised the exothermic reaction in part **(a)** and a considerable number could construct the word equation and select the conditions for the synthesis of ethanol by hydration of ethene. Few could complete the structure of ethanol in part **(b)** or suggest how ethanol can be purified from a fermentation mixture in part **(c)**.

(a) Nearly all the candidates recognised the temperature rise indicates an exothermic reaction. The commonest error was to refer to the bubbles.

(b) A minority of candidates completed the structure of ethanol correctly. The commonest errors were: drawing the structure of methanol; drawing the structure of ethane; omitting hydrogen atoms or joining the H to the carbon e.g. C – H – O.

(c)(i) Many candidates wrote the correct word equation for the synthesis of ethanol. The most common errors were: writing the steam/ water over the arrow or giving extra products e.g. oxygen or hydrogen. A few wrote ethane instead of ethene.

(ii) Many candidates selected the correct conditions for the hydration of ethene. The commonest errors were to suggest presence of light or enzyme catalyst.

(iii) Few candidates knew the test for an unsaturated compound using bromine water. Many gave the answer that 'the bromine water stays orange/ brown'. Others suggested that there would be a precipitate or gave colours such as blue or green.

(d) A minority of the candidates suggested filtering the mixture first. Most realised that distillation was required although most stated 'simple distillation' rather than the correct 'fractional distillation'. A number of candidates did not respond to this question.

Question 3

A majority of the candidates were able to identify the cathode from a diagram and complete the word equation for the electrolysis of sodium bromide. Few could explain the meaning of the terms *electrolysis* or *isotopes*. Some were able to interpret the diagram in part **(d)** correctly. Others gave answers which were vague or contradictory.

(a)(i) Few candidates gave a correct definition of electrolysis. Some did not mention an electric current or include the important words 'breakdown' or 'decomposition' in their answers. A common error was to suggest that electrolysis is a way of separating elements or compounds. A minority of candidates incorrectly suggested 'the breakdown of elements'.

(ii) Many candidates identified the cathode correctly. The commonest error was to suggest **S**.

(b) Most candidates were able to deduce at least one of the electrolysis products. The commonest error was to suggest 'bromide' instead of bromine. A considerable minority suggested elements other than those present in sodium bromide e.g. zinc.

(c) Nearly all candidates recognised that a neutral solution has a pH value of 7. The commonest error was to suggest pH 0.

(d)(i) Few candidates recognised that the charged particles in sodium bromide were ions. Many suggested 'atoms'.

(ii) Many candidates recognised that the diagram represented a solid but very few gave two reasons. The commonest error was to write about how the particles moved. Most responses included the idea of the particles being close together or touching. Others gave vague statements such as 'they are closer together than in a liquid'. Only a minority of candidates recognised that the ions were regularly arranged.

(e) Many candidates balanced the equation successfully. The commonest error was to put Br or 2Br instead of Br_2.

(f) Few candidates gave a good definition of the term 'isotope'. The most common errors were to write about substances or molecules rather than atoms or elements. Many wrote vague statements such as 'they have different numbers of neutrons'.

Question 4

This question was generally well answered. The extraction of information from the graph and the construction of a line to show how the volume of gas changed at a lower temperature in part **(b)** was not always well done. Few candidates were able to draw the electronic arrangement in a hydrogen molecule in part **(c)(i)** and even fewer could give the names of two compounds which react together to form magnesium sulfate in part **(d)**. Nearly all recognised that powdered magnesium reacts faster than magnesium ribbon with hydrochloric acid.

(a) Many candidates recognised that the evolution of a gas was responsible for the mass loss in the reaction between magnesium and hydrochloric acid. The commonest errors were: suggesting that the hydrochloric acid evaporated; suggesting that the products were 'lighter' than the reactants or that the cotton wool was somehow involved in the reaction. Some candidates compromised their answers by writing that the 'gas is absorbed by the cotton wool'.

(b)(i) Many candidates misread the graph and gave a time of 40 seconds.

(ii) Some candidates read the time from the graph accurately. Others assumed that the line went through the 40 cm^3 rather than 41 cm^3. A considerable number did not respond to the question.

(iii) Many candidates realised that they had to draw a line with a lower initial gradient. Fewer recognised that the line should reach the same final volume. A considerable minority did not start their curve at the origin.

(iv) Nearly all candidates realised that the reaction with magnesium powder would be faster than that with magnesium ribbon. Some tried to write explanations but this was not necessary.

(c)(i) Most candidates drew a diagram of a hydrogen atom rather than a hydrogen molecule, sometimes without an electron.

(ii) Many recognised that the bonding in a hydrogen molecule is covalent. The commonest errors were to suggest ionic or to write answers which were not related to bonding.

(d) A majority of the candidates did not acknowledge the word 'compound' in the stem of the question and suggested adding magnesium to sulfur. Only a few suggested suitable magnesium compounds, magnesium salts being the commonest suggestions. A greater number of candidates suggested correctly, that the acid should be 'sulfuric acid'. Some incorrectly suggested 'hydrochloric acid'.

Question 5

Some parts of this question were reasonably well done especially most of part **(b)**. Part **(d)** was considered by most candidates to be a question about chromatography rather than about the extraction of colour from grape skins. Many did not recognise the carboxylic acid group in part **(a)**.

(a) A minority of candidates recognised the carboxylic acid group. Common errors included: ringing the carbonyl group or the alcohol group. Others ringed several parts of the structure.

(b)(i) A considerable number of candidates did not respond to this question. Those who did often calculated the relative molecular mass correctly. The commonest errors were the use of atomic masses or not including both hydrogen atoms in the calculation.

(ii) Nearly all the candidates could describe the function of a catalyst.

(iii) The effect of carbon monoxide on human health was well recognised. The commonest errors were to suggest that it caused lung diseases or cancer. Many candidates wrote answers relating to haemoglobin which were acceptable.

(c)(i) Candidates who performed less well gave responses that were too vague or confusing e.g. 'it reduces the oxygen'. A considerable minority wrote about atoms being taken away.

(ii) Some candidates chose carbon as the correct reducing agent. The commonest error was to suggest copper and a few candidates suggested carbon dioxide.

(d) Most candidates misunderstood the question and described the process of chromatography rather than the extraction of pigments. Many gave a method of crushing the grapes but fewer mentioned the addition of a liquid. Common errors included 'squeezing the grapes to get the juice' or 'putting the grape skins on chromatography paper'. A considerable number of candidates did not respond to this question.

(e) Many candidates gave the correct monomer. The common errors were to suggest the catalyst or 'poly(ethene)'.

(f)(i) Most candidates realised that a high temperature is needed for cracking. Only a minortiy went on to mention use of a catalyst.

(ii) The equation for the cracking of hexadecane was generally completed well. There were no consistent errors.

Question 6

This was the least well answered question on the paper. Part **(a)(iii)** (the conversion of iron into steel) and part **(b)** (comparison of lithium and potassium with water) were not always well answered. Most other parts were well done.

(a)(i) Many candidates were able to extract relevant information from the table. The most common error was to confuse the properties of the Group I elements with those of other metals. Some thought that Group I metals were transition elements.

(ii) The properties of transition elements were not very well known. Some candidates described the general properties of metals rather than those of the transition elements.

(iii) The most common error was to give '$2H_2$'.

(iv) This was the least well answered question on the paper. Many candidates confused steelmaking with the extraction of iron in the blast furnace. Most realised that oxygen was involved and a few mentioned the addition of calcium oxide or adding other metals to make the steel. A few of the better performing candidates mentioned oxidation of impurities but few mentioned the nature of the impurities in the iron.

(b) Some candidates wrote statements such as 'potassium produces bubbles' rather than 'potassium produces more bubbles'. Few candidates knew both products of the reaction. 'Hydrogen' was frequently suggested but 'potassium oxide' or 'lithium oxide' were common incorrect answers.

Question 7

This was the highest scoring question on the paper for many candidates. Parts **(a)** and **(b)(iii)** were the least well done. Many could extract information for the table in part **(b)(i)** and deduce the numbers of electrons, protons and neutrons from given information in part **(c)**.

(a) Better preforming candidates gave a good description of the compressibility and an explanation in terms of the proximity of the particles. Others either did not mention the change in volume of the syringes or write vague statements about the proximity of the particles in water e.g. 'they are further apart in gases than in water' or 'the particles in water are not very far apart'.

(b)(i) A majority of the candidates correctly identified the trend in density.

(ii) A majority of the candidates were able to deduce the electron arrangement of neon. The commonest error was to suggest 2,8,8.

(iii) Many candidates suggested, incorrectly, that argon is a solid at -188^{o}C. A minority suggested that it is a gas at this temperature.

(iv) The correct gas (krypton) was chosen by many candidates. Others generally chose helium. Very few chose other gases.

(b) Most candidates identified the number of neutrons in helium and the number of electrons in argon from the data given in the table. The commonest error was to suggest that neon has a mass number of 20.

CHEMISTRY (US)

Paper 0439/23

Core Theory

Key Messages

- It is important that candidates read questions carefully in order to understand what is exactly being asked.
- Many candidates need more practice in answering questions about the reactions of the halogens with halide ions.
- More practice is needed in drawing diagrams of apparatus involved in practical procedures and in answering questions about qualitative tests for particular compounds.
- Interpretation of data from tables and answering simple questions about structure, electron arrangement and diffusion were generally done well.

General Comments

Many candidates tackled this paper well, showing a good knowledge of Core Chemistry. Nearly all candidates were entered at the appropriate level. The standard of English was generally good. Some of the questions were left unanswered by a minority of candidates. This was especially apparent in **Questions 2(a)(ii)** (formula of ethanoic acid), **5(c)(ii)** (use of the naphtha fraction) and **5(d)(i)** (source of methane).

Some candidates need more practice in reading and interpreting questions. For example in **Question 4(c)(i)** many candidates selected zinc rather than a zinc compound, whilst in **6(b)** some wrote about the reaction of chlorine with potassium bromide and potassium iodide.

Many candidates were unable to distinguish between atoms, molecules and ions and between compounds and elements. Chemical definitions such as those for isotopes and electrolysis were recalled by few candidates.

Some candidates need more practice in recalling the results of simple chemical tests e.g. the test for water using anhydrous copper sulfate and the tests for halide ions and nitrates.

Some candidates need more practice in drawing the apparatus used for filtration (**Question 3(c)**) and in interpreting the results of practical procedures (**Question 4(a)**)

Many candidates were able to extract information from tables and complete word equations. Some were able to draw the arrangement of electrons in a molecule of chlorine, identify functional groups and complete the structure of ethanoic acid.

Questions involving general chemistry including rates of reaction and the particulate nature of matter were well tackled by many candidates.

Comments on specific questions

Question 1

Most candidates identified at least three of the structures correctly in part **(a)**. Fewer could give the correct name of compound B in part **(b)(i)**.

(a) In part **(i)** many candidates identified **C** as being an element. In part **(ii)** most candidates recognised **A** as being a substance that turns red litmus blue. The most common incorrect answer was **B** (sodium nitrate). In part **(iii)** the most common incorrect answer was **A** (ammonia) or **E** (sodium chloride). In part **(iv)**, many candidates chose **D** rather than **E**. A variety of answers were seen in response to part **(v)**, where many candidates chose one of the other ionic structures or **A**.

(b)(i) Some candidates gave the correct name for **B** (sodium nitrate). Others tried to create names such as 'sodium nitroxide' or 'sodium nitric acid'.

(ii) Common errors included, 'liquid' in the first answer space and 'atoms' in the last answer space. There were no consistent errors for the other spaces.

Question 2

Nearly all candidates recognised the exothermic reaction in part **(a)** and a considerable number could recognise the characteristic properties of a homologous series in part **(b)**. A minority of the candidates were successful in completing the structure of ethanoic acid in part **(a)(ii)**. In part **(c)** some candidates appeared to misunderstand the word 'observations'.

(a)(i) Most candidates recognised the temperature rise as indicating an exothermic reaction. A few candidates incorrectly referred to the bubbles.

(ii) Few candidates were successful in completing the structure of ethanoic acid. The most common errors were: omission of one of the oxygen atoms; five bonds to the carboxyl carbon atom; double bonds between oxygen and hydrogen atoms and structures with too many hydrogen atoms. A significant number of candidates did not respond to this question.

(iii) Some candidates gave vague answers for this part, which did not explain the crystallisation process well enough. Many candidates just suggested heating the crystals to dryness. Few mentioned drying the crystals with filter paper.

(b) Most candidates were able to describe the characteristics of a homologous series. The most common error was to suggest that they have the same physical properties.

(c) Many candidates were able to suggest at least one observation when ethanoic acid is added to magnesium. Others did not give observations but wrote about 'gas given off', 'a magnesium compound is formed' or 'there is a change in the pH'.

Question 3

Many candidates performed well on this question especially in parts **(a)** and **(b)(ii)**. The interpretation of the diagram in part **(a)(iii)** and the drawing of a labelled diagram to show filtration were poorly attempted.

(a)(i) Many candidates identified the change from copper sulfate to copper oxide as thermal decomposition. The most common error was to suggest oxidation.

(ii) Many candidates chose appropriate safety procedures for dealing with sulfur trioxide but few mentioned using a fume cupboard. Some candidates gave vague statements about 'keeping away from the reaction' or 'don't breathe in the gas'.

(iii) Some candidates realised that the sulfur trioxide was a liquid; others thought it was a solid. Many misinterpreted the diagram and suggested that the particles were 'a little away from each other' or that there are 'large spaces between the particles'. Many wrote about the movement of the particles, even though the diagram did not show that. Some candidates incorrectly suggested that the particles were regularly arranged.

(b)(i) Some candidates wrote the formula for sulfuric acid correctly. Others missed off a hydrogen atom or added other atoms.

(ii) Nearly all the candidates recognised the pH value which was strongly acidic. The most common error was to suggest pH 13.

(c) A few candidates drew neat, well-labelled diagrams to show filtration. Common errors were: placing a sheet of filter paper flat across the top of the filter funnel; not using any filter paper or not labelling the apparatus. A considerable minority of candidates incorrectly drew apparatus with condensers, burettes or other pieces of glassware.

(d)(i) Many candidates recognised the symbol for a reversible or equilibrium reaction. Those who did not, often referred to 'equality'.

(ii) Some candidates recognised the test for water involving anhydrous copper(II) sulfate. Others muddled it with the litmus test and wrote red and blue instead of white and blue. A wide range of other colours were seen.

Question 4

This question was generally well answered, with many candidates giving good answers for the questions involving reaction rate. Fewer candidates could explain the loss in mass of the flask in part **(a)** and in part **(c)(i)** few candidates could name a suitable zinc compound which reacts with hydrochloric acid to form zinc chloride.

(a) Some candidates recognised that the evolution of a gas was responsible for the mass loss in the reaction between zinc carbonate and hydrochloric acid. The most common errors were: suggesting that the hydrochloric acid evaporates; suggesting that solids are lost from the flask or implicating the cotton wool in the reaction.

(b)(i) Many candidates recognised that the mass decreases with time. Fewer wrote about the mass staying the same after about 40 seconds.

(ii) The reaction time was deduced correctly by some candidates. Others misread the graph and gave values for reaction time which were considerably outside the allowed range.

(iii) Many candidates calculated the decrease in mass correctly. The most common errors were to suggest 135 g or 196 g.

(iv) Some candidates drew good graphs to show how the mass of the reaction mixture changes when the experiment is carried out at a higher temperature. Others drew a line with a steeper initial gradient but ended the line at a lower volume, rather than reaching the same final volume. A considerable minority drew the line with a shallower initial gradient or drew a straight line cutting the curve already drawn on the graph.

(v) Many candidates realised that the reaction with large pieces of zinc would be slower than that with smaller pieces.

(c)(i) A considerable number of candidates did not appear to read the stem of the question carefully enough and suggested the element zinc rather than a compound of zinc. Those who did suggest the name of a compound tended to suggest a chloride or other salt rather than an oxide, hydroxide or carbonate. A considerable minority of candidates did not respond to this question.

(ii) The products of the electrolysis of zinc chloride were not always recognised. Some candidates gave the names or formulae of the ions rather than the elements. Others wrote the products at the incorrect electrodes. A considerable minority gave elements which were not present such as copper.

Question 5

This was generally the least well answered question on the paper. Few candidates realised the link between petroleum fractions and the boiling points of the molecules. Many could not give a suitable use for the naphtha fraction. In part **(a)** some candidates responded well to the questions referring to the formula of linalool.

(a)(i) Some candidates were able to identify the alcohol functional group. Others drew a circle around the double bond or included a carbon atom attached to the OH group. Another common error was to put a ring around the $(CH_3)_2C=$ group.

(ii) Most candidates deduced the number of different elements present in linalool. The most common error was to suggest '4'. Some candidates suggested '10' or higher numbers.

(iii) Many candidates counted the number of carbon atoms correctly. The most common error was to suggest 9 carbon atoms.

(iv) Some candidates recognised that the compound was unsaturated. Many incorrectly thought that the CH_3 groups or the OH group were responsible for unsaturation.

(b)(i) Most candidates gave a nearly correct sequence for the purification procedure. Few got the sequence completely correct.

(ii) Few candidates realised that fractional distillation depends on boiling points. Most gave vague answers relating to other physical properties such as density.

(c)(i) The main errors in this part were to place **H** in the next compartment from the bottom or to place **X** either at the bottom of the column or somewhere in the middle.

(ii) A minority of candidates gave a suitable use for the naphtha fraction, usually for making chemicals. A wide variety of incorrect answers were seen ranging from roofs to natural gas. A considerable minority of candidates did not respond to this question.

(d)(i) Some candidates gave a correct source of methane often from animal sources. Others referred to other petroleum fractions or from particular chemicals. A considerable minority of candidates did not respond to this question.

(ii) Many candidates referred to global warming or the effects of global warming. The most common error was to suggest that methane is responsible for depleting the ozone layer.

(iii) Many candidates suggested, incorrectly, that methane belongs to the alkene or alcohol homologous series. Others gave answers which did not relate to any homologous series.

Question 6

This was the best answered question on the paper. The exception was in part **(b)** (reactions of the halogens with the halides) where very few candidates answered this part well.

(a)(i) Most candidates were able to extract relevant information from the table and deduce which elements are giant covalent structures. The most common error was to suggest that they have low melting points or to try to relate the structure to their colour.

(ii) Some candidates were able to link the structure of graphite with its electrical conduction. A considerable number of candidates suggested that either **C** or **D** was graphite because it did not conduct.

(iii) Most candidates correctly identified chlorine from its colour. The most common error was to suggest **D**.

(b) Many candidates gave statements that encompassed both reactions at the same time and hence the answers were confused. Most candidates thought that there would be a reaction of bromine with both potassium chloride and potassium iodide. Only the better performing candidates commented on the relative reactivity of the halogens. A considerable minority of candidates wrote about the reaction of chlorine with potassium bromide and potassium iodide.

(c) Many candidates commented on the ability of chlorine to kill bacteria or other microorganisms. The most common error was to write vague answers such as ‘it purifies the water’ or ‘the water is cleaned’.

(d) The electron arrangement of chlorine was well known. The most common error was to omit the bonding pair of electrons.

(e)(i) Many candidates were able to deduce the molecular formula for indium chloride. The most common errors were either to reduce the formula to $InCl_3$ or to miscount the atoms to give In_2Cl_4 as a common example.

(ii) Most candidates deduced the number of protons correctly.

Question 7

Parts of this question were well answered by the majority of the candidates e.g. **(c)(i)** and **(d)(ii)**. Few could explain the term *volatile* in part **(a)** or suggest why it is difficult to predict the melting point of butane from the data given in part **(c)**. The question on diffusion in part **(b)** was answered well by many candidates.

(a) Very few candidates understood the meaning of the term *volatile*. Many gave answers relating to the smell of the perfume or thought that it meant poisonous.

(b) The best candidates gave a good description of diffusion in terms of particles moving down a concentration gradient and moving randomly. Common errors were: not to mention particles at all (just reference to the smell); not mentioning the term diffusion or to suggest that the particles move in a direction from low to high concentration.

(c)(i) Many candidates were able to deduce the pattern of change in boiling points from the information in the table. The most common error was to suggest that boiling point decreases as the number of carbon atoms increases. A minority of candidates tried to relate the pattern to the melting points rather than the number of carbon atoms.

(ii) Better performing candidates commented on the irregularity of the pattern in the melting points of the alkenes as the number of carbon atoms increases. The most common errors were to either write about 'not knowing the state' or suggesting that it had something to do with the formulae.

(iii) Many candidates identified the CH_2 group as having a relative mass of 14. The commonest error was to suggest CH_3.

(iv) The word equation for the combustion of ethene was not well known. Many candidates omitted oxygen as a reactant and a variety of incorrect hydrogen-containing products was seen including hydrocarbons and hydrogen. Many candidates gave products which did not contain hydrogen.

(d)(i) Some candidates gave a good definition of the term isotopes mentioning atoms or elements. Others gave answers which were far too vague involving molecules or compounds. Some candidates confused atomic number and mass number. A minority of candidates wrote about radioactivity.

(ii) Most candidates were able to write a symbol for carbon-12 showing the mass number and proton number. The commonest error was to suggest that there are 4 protons.

CHEMISTRY (US)

Paper 0439/31

Extended Theory

Key Messages

Candidates need to be reminded to read each question thoroughly before attempting to answer the question. Questions **1(c)(i)**, **3(b)(i)** and **6(a)(i)** were cases in point where candidates missed the point of the question and wrote answers which included sound chemistry but were irrelevant to the question posed.

Candidates need to be reminded that if, say, **one** use of a substance is asked for, then no more than *one* use should appear in the answer as any incorrect uses given will be viewed as a contradiction to correct uses.

Candidates need to be reminded that a word equation, unless specifically asked for, will receive no credit in place of a correct symbol chemical equation.

Some good examination techniques were seen by underlining of command words in the questions. However, some responses were a rewriting of the question. Candidates should look to make answers concise and keep to the space available. Simple use of bullet points rather than long rambling paragraphs may help candidates hit the key points of an answer.

General Comments

Candidates seemed well prepared for the question paper. There was no evidence that there was insufficient time to complete the paper and there was little evidence of problems in understanding the questions.

Comments on Specific Questions

Question 1

(a) Candidates were told that coal is a fossil fuel and were asked to name two *other* fossil fuels. Many erroneously included coal as one of the *other* fossil fuels. Candidates need to be aware that vague answers such as ‘oil’ or ‘gas’ would receive no credit. Unfortunately a few candidates were unaware that crude oil and petroleum are the same thing. And once again it should be stressed that only two other fossil fuels were asked for.

(b) Good candidates had no problems here but weaker candidates struggled and a variety of elements and compounds were seen. Once again, many candidates did not read the question which asked for three *other* elements apart from carbon and sulfur which were given in the question and both these elements were frequently seen in responses.

(c) (i) Good candidates were able to realise that oxides of nitrogen formed inside an internal combustion engine and reacted with or dissolved into atmospheric water to form acid rain.

Many candidates wasted time by describing the formation of sulfur dioxide and sulphuric acid again, rather than *another* cause of acid rain.

There were three marks available and candidates should be eminded that three points should be looked for. This may have prevented dissolution/reaction with water of the gas being frequently omitted.

(c) (ii) Most candidates knew two harmful effects of acid rain although contradictory answers such as ‘acidifies lakes and increases the pH levels’ were frequently seen.

(d) Candidates found this question difficult. There was fairly extensive ignorance of the nature of wood and awareness of need to apply carbon cycle to answer this question. Many weaker candidates believed that wood does not contain any carbon and would not produce any CO_2 on burning, or any other gases, and very few realised the relevance of photosynthesis leading towards carbon neutrality.

Question 2

(a) Good candidates often secured all five marks on this question. It was expected that candidates would know that the oxide of all four elements would form and that carbon dioxide and sulfur dioxide would be removed as gases. The removal of the solid acidic oxides depended needed their reaction with calcium oxide.

It was evident that many candidates were unaware of how steel is manufactured and some jumbled responses were seen. Others simply trotted off the reactions and processes of the blast furnace. Of those who were correctly describing steel manufacture, the frequent error was to assume calcium oxide reacted directly with silicon or phosphorus in order to emove these elements as slag.

(b) (i)(ii) Most could provide a use for mild steel but found a use of hard steel more challenging.

(iii) Weaker candidates often confused electrical conductivity and melting points. Only the good candidates were able to realise that a simple phrase such as 'layers of ions slide over each other' would succinctly answer the question.

(iv) Stronger candidates realised that in hard steel, the sliding was restricted but only a minority stated that the reason for this was that the carbon atoms are a different size.

Weaker candidates produced responses with a lot of repetition of the question and with figures for the percentages of carbon contained in both types of steel but no explanation offered for the malleability differences.

Question 3

(a) (i)(ii) These parts were well answered but some candidates just gave 'hydrogen'/'H' rather than the 'hydrogen ion'/'H^+' as the oxidising agent.

(b) (i) A large proportion of candidates wrongly assumed the question meant 'copper chloride' when it clearly asked for 'copper'. Other candidates chose to write irrelevant statements about copper being a catalyst and speeding up the reaction. Where equations were given it was extremely rare to see an attempt to write the expected equation for the displacement reaction between zinc and copper chloride.

(ii) Candidates failed to explain how graph 2 showed copper to be a catalyst (i.e. steeper gradient suggesting an increased rate of reaction but producing the same volume of hydrogen) and luckily scored a mark for a random statement about 'a faster reaction'.

(c) It was expected that candidates would know that ethanoic acid is weaker than hydrochloric acid so would ionise less leading to a slower rate of reaction and a lower gradient on the graph. However, weaker candidates assumed ethanoic acid to be stronger often for spurious reasons such as 'it had more H atoms'.

(d) Although strong candidates coped well, this unstructured calculation proved very difficult for the majority and frequently the score was zero. Candidates are advised that they do need to state what their calculation is attempting to determine and to include as many words as possible amongst their figures, even if this is just units. In that way 'method marks' for an 'error carried forward' can be awarded. However if the examiner just sees a jumble of numbers it is very difficult to award marks in the absence of a correct answer. It was evident that there was confusion with the molar gas volume as the number '24' featured amongst many other figures frequently.

Question 4

It was clear that some candidates had little knowledge of the organic section of the syllabus and it was further evident that this was a Centre-based problem. Centres are advised to concentrate upon all areas of the syllabus with equal rigour.

(a) (i) Most candidates could give at least one characteristic of a homologous series. Many candidates erroneously assumed that members of a homologous series share similar physical properties. Once again some candidates gave more than the three characteristics asked for.

(ii) Most candidates were aware that propanol was the third member of the alcohol homologous series.

(iii) Candidates coped well with this calculation and most were able to determine that the alcohol had 10 carbon atoms, 22 hydrogen atoms as well as the one oxygen atom. Where they often slipped up was assuming that the molecular formula was $C_{10}H_{21}OH$ when in fact it was $C_{10}H_{22}O$. However, they were not penalised for the error this time.

(b) Most knew why the two structures were isomers.

(c) (i) The dehydration reaction of alcohols was not widely known and many candidates assumed that a silicon based organic compound was formed – despite being told that silicon(IV) oxide was a catalyst in the question. Candidates are advised to check that they are not drawing structures with pentavalent C atoms.

(ii) There were a lot of blank responses to this straightforward question. Where candidates knew about esters then butyl ethanoate was identified as the ester although the occasional 'ethyl butanoate' was seen.

(iii) The oxidation product from butan-1-ol was not well known. Many guesses which included either 'potassium' or 'manganate' from the oxidising agent were frequently seen.

Here too, candidates are advised to check that they are not drawing structures with pentavalent C atoms.

Question 5

(a) It was clear that many candidates had not seen this simple displacement experiment as many blank responses were seen. It was expected that candidates would add chlorine to an aqueous solution of an iodide and that the appearance of the yellow-brown coloration of iodine would be proof of the relative reactivity of the halogens. All too frequently candidates gave a word equation for the reaction instead of the expected symbol equation.

(b) Candidates coped well with this calculation to determine the formula as being IF_5, although a significant number assumed fluorine to have the symbol 'F*l*'.

(c) (i) It was expected that candidates would use their knowledge of the syllabus and come up with a straightforward reversible reaction such as heating hydrated copper(II) sulfate crystals or the Haber process. Many opted for physical changes which were not given credit as these are not reactions and some enterprising candidates simply replaced the C*l* atoms in the equation given for another halogen such as Br.

(ii) Candidates realised that an equilibrium is a reaction which can occur in both directions and at the point of equilibrium the macroscopic properties such as concentration do not change as the rates of forward and backward reactions are equal. A significant number wrongly stated that the concentration of the products was equal to the concentration of the reactants.

(d) Many candidates failed to refer to shift in equilibrium or gave unclear explanations of shift in equilibrium. Many weaker candidates re-stated the colour changes rather than why they occurred. Many candidates gave contradictory statements about equilibrium shifts, e.g. 'the equilibrium shifts to the left hand side, towards the products'.

(e) Candidates generally understood that the forward reaction was exothermic but could not relate this to the forward shift in equilibrium.

Question 6

(a) (i) Although a difficult question, all too often candidates failed to address the question and omitted any mention of protons thus nullifying any chance of credit.

(ii) Many candidates made good attempts at this and sensible uses and outcomes of suitable indicators (such as pH paper and universal indicator) were frequently seen. Although many irrelevant 'fair test' conditions such as temperature and volume of base were given, only a minority of candidates realised that it was essential to keep concentration constant in order for the comparison to be 'fair'.

(b) (i) This difficult equation was completed successfully by only the strongest of candidates, although a significant number of candidates were able to work out the name of the salt produced. The most frequent error was to assume the sulfate group had a charge of minus one.

(ii) Only the stronger candidates could name a strong base with sodium hydroxide being the preferred choice. Many weaker candidates opted for sodium chloride.

(c) (i) The process of diffusion was reasonably well understood with most candidates receiving some credit.

(ii) There were many good answers to this question but often candidates assumed the molecule with the larger number of atoms must be 'heavier' and gave the answer the wrong way round. However, credit was still awarded for 'correct' explanations based upon this false premise. It was expected that candidates would refer to ethylamine having a lower relative molecular mass or lower density. This would mean that ethylamine would diffuse quicker or its *molecules* would travel faster.

Candidates who wrote about ethylamine being 'lighter' and 'ethylamine moving quicker' received no credit.

CHEMISTRY (US)

Paper 0439/33
Extended Theory

Key Messages

Candidates need to read questions fully and with care to ensure they are in possession of all the information provided and that they are trying to answer all aspects of the question asked.

General Comments

A surprising number of answer spaces were left blank. The overall quality of answers was very variable.

Comments on Specific Questions

Question 1

(a) This opening question was poorly answered. As well as errors in the valencies of the elements concerned, candidates used incorrect symbols, superscripts rather than subscripts and inserted what looked like stoichiometric coefficients before the formulae.

(b) A significant number of candidates ignored the word 'ions' in the question and wrote species without a charge.

(c) While many fully correct answers were seen, common errors included having only single bonds (one shared pair of electrons) between each oxygen atom and the carbon atom, missing out the non-bonding electrons on the oxygen atoms and adding extra non-bonding electrons on the carbon atom.

Question 2

(a) This was not well known: aluminium, copper or silicon oxides were common errors.

(b) The alkaline nature of sodium oxide was well known.

(c) The use of sulfur dioxide as a bleach was well known.

(d) Aluminium oxide was seen more commonly than zinc oxide. A common error was carbon monoxide.

(e) This proved more difficult than expected, with a significant number writing carbon monoxide (possibly getting mixed up with the structure of diamond or graphite).

(f) The acid nature of sulfur dioxide was well known.

Question 3

(a) This was very poorly answered. Very few candidates referred back to the equation and noted that a gas was made which would escape. Many stated that the reaction is not reversible, despite the use of ⇌ in the equation.

(b) Many candidates ignored the information written in the question and did not start with calcium oxide nor make calcium hydroxide. Some wrote word equations; unless a word equation is asked for in a question then all equations should be balanced chemical equations.

(c) A good number of fully correct answers were seen; disappointingly these often lacked any clear working. There were also many answers that scored zero, with candidates not knowing where to start with this straightforward calculation. A common error was to use the conversion factor for tonnes into grams that was given in the question as the mass of one of the species, careful reading of the question would have avoided this error.

(d) In **(d)(i)** most candidates were able to state that calcium carbonate being insoluble was an advantage, often giving excellent explanations of its resistance to being washed away by rain. However, a significant number of candidates gave answers suggesting that they thought calcium carbonate was a fertiliser and provided the plant with substances required for growth. In contrast, **(d)(ii)** was very poorly answered and was not attempted by a significant number of candidates. Some answers were very confused, stating that the sulfur in the gas was removed by calcium carbonate by converting it into sulfur dioxide. The best answered section of this question was **(d)(iii)**, many candidates could correctly state a use of calcium carbonate, the most common use given being in the making or steel/extraction of iron.

Question 4

(a) In **(a)(i)** the majority of candidates could name another fossil fuel, but in **(a)(ii)** many explained either what a fossil was or what a fuel was, but rarely both. As both words were in *italics*, the answer should have explained the meaning of the complete term.

(b) The first part of the question, **(b)(i)**, was poorly answered; some very confused answers were seen, with candidates stating that there is sulfur in the air or trying to describe chemistry which bordered on alchemy with carbon dioxide reacting to form sulfuric acid. Despite the chemistry in **(b)(ii)** featuring in previous series of this examination, it was very poorly understood. Some answers involved hydrogen from the air reacting with nitrogen and water to make nitric acid. The test for nitrate ions in **(b)(iii)** was not well known; candidates need to learn the simple ion tests – the data sheet describing them is given to candidates only on papers 51, 52 and 53. Some interesting and innovative answers were seen in **(b)(iv)** and full credit was given for any method that would work. Unfortunately some candidates managed to contradict themselves by stating that the pH could be measured and that the acid with the higher concentration of hydrogen ions would be more acidic – having the *higher* pH.

Question 5

(a) Many candidates failed to read the question carefully, if they had done so they would have seen that copper(II) oxide should be made in all three reactions and so they may have written equations that did have copper(II) oxide as a product. Part **(a)(i)** was the part most commonly correctly answered, in **(a)(ii)** hydrogen was sometimes seen as a product. Very few candidates scored full marks in **(a)(iii)**: even those with correct products sometimes forgot to balance the equation.

(b) In **(b)(i)** a surprisingly small number of candidates knew the colour of copper oxide, often stating that the starting colour would be blue. When a question asks for a colour change both the start and finish colour should be stated, simply stating one colour is not a colour change. Part **(b)(ii)** was well answered, with many candidates realising that the copper would react with the oxygen in the air; however, some candidates were grasping at straws with answers such as ‘it will explode’. The reduction of copper oxide by hydrogen or methane is simple to set up and a reaction with which candidates should be familiar. It was disappointing in **(b)(iii)** that many candidates gave hydrogen as the answer (the gas used in the question rather than another gas) or gave the name of a substance which was certainly not a gas. The final part, **(b)(iv),** was well answered with most candidates selecting a more reactive metal.

(c) Most candidates were able to correctly complete the table in **(c)(i)**, but very few fully correct answers were seen in **(c)(ii)** – most candidates could identify which sample was impure, but could not then relate this to how the sample of copper(II) oxide had been made.

Question 6

(a) While many candidates were able to give the correct formula for the aluminium ion in **(a)(i)**, fewer were able to construct a correctly balanced equation. Triatomic aluminium or three moles of aluminium were seen as products, presumably due to confusion over the meaning of the superscript '3' in the formula of the aluminium ion. Few fully correct equations were seen in **(a)(ii)**: some candidates got close but either failed to make diatomic oxygen molecules or had half the required number of electrons. In **(a)(iii)** the answer 'exothermic' was very common (presumably because most reactions are exothermic) and some candidates ignored the instruction that an explanation was required.

(b) Again in **(b)(i)** some candidates ignored the instruction that they had to explain their answer. In **(b)(ii)**, while a good proportion of candidates could give a reason why the magnesium electrode lost mass, many fewer could explain why the copper electrode gained mass; the most common error being that copper gains electrons rather than copper *ions* gain electrons (and are so deposited as copper atoms). Once again in **(b)(iii)** many candidates did not read the question properly and so did not try and use the cell in the question; instead they just described a displacement reaction and so gained no credit as they had not answered the question asked.

(c) While some fully correct equations were seen, some candidates lost marks by failing to balance their equations. A surprising number of candidates made products other than carbon dioxide and water and so could gain no credit.

(d) The source of energy for photosynthesis was well known in **(d)(i)** and many correct equations were seen in **(d)(ii)**. However, some candidates again did not read the question carefully and so made things difficult for themselves by trying to write balanced symbol equations.

Question 7

(a) This was the best answered section of the examination paper. The majority of candidates gained full marks in **(a)(i)** and **(a)(ii)**. However, despite the test for unsaturation of a hydrocarbon being examined regularly, **(a)(iii)** was poorly answered; those candidates who knew the test reagent (bromine) often failed to score full marks because they did not state somewhere in their answer the starting colour of the bromine.

(b) Many candidates were able to go from the structure of the monomer in **(b)(i)** to the polymer structure, but errors such as failing to show the structure repeated resulted in full marks not being awarded to many candidates. Once again in **(b)(ii)** some candidates lost marks through failing to read the question carefully and drawing the structure of the repeat unit of the polymer rather than the structure of the monomer. Part **(b)(iii)** was very poorly answered: it was clear that few candidates had come across the term 'addition' and 'condensation' in relation to polymers. The final part on the examination paper, **(b)(iv)**, was simple recall, yet this was the question part most often not attempted on the entire paper and was one of the lowest scoring question parts on the paper.

CHEMISTRY (US)

Paper 0439/04

Coursework

General Comments

This is the final June series for this paper and the vast majority of Centres submitted samples of work that required no adjustment.

The tasks chosen were usually appropriate and the standards applied by the Teachers at the Centres were also appropriate.

Much excellent work was read by Moderators which reflects well on the Teachers and candidates in the Centres.

Where there were occasional problems, it was usually due to the tasks chosen by the Centre not being entirely suited to the assessment of the skill concerned. Over generous marking by the Teachers at Centres was relatively rare.