CHEMISTRY (US)

Paper 0439/11
Multiple Choice (Core)

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

General comments

Candidates performed well on this paper.

Questions 8, **36** and **40** were particularly straightforward.

Candidates found **Questions 10**, **32** and **39** more challenging.

Comments on specific questions

Question 2 – Response D

Candidates did not appreciate that both parts of the mixture had to be obtained.

Question 4 – Response A

Candidates were confused by the negative temperatures. This response was more popular than the correct one.

Question 5 – Response B

Candidates did not understand the difference between a compound and a mixture. This response was as popular as the correct answer.

Question 10 – Responses A and D

Both responses **A** and **D** were equally popular and were more popular than the correct answer.

Question 19 – Response C

Candidates did not realise that the zinc sulfate was in solution.

Question 27 – Response C

This response was more popular than the correct answer. Candidates may have thought that the reduction of an oxide with carbon showed that the metal is reactive.

Question 28 – Response A

Stainless steel is not commonly used for car bodies.

Question 32 – Responses B, C and D

All responses had an approximately equal numbers of candidates choosing them, suggesting that a high proportion of candidates were guessing the answer.

Question 39 – Response A

Candidates selected the incorrect process for the conversion of ethene into ethanol.

CHEMISTRY (US)

Paper 0439/21
Multiple Choice (Extended)

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

General comments

Candidates performed well on this paper.

Questions 15 and **25** were particularly straightforward.

Candidates found **Question 40** more challenging.

Comments on specific questions

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

Question 1 – Response A

A significant number of candidates did not know what *condensation* means.

Question 8 – Response D

Candidates simply found the ratio of the percentages, ignoring the mass numbers of the elements. This answer was more popular than the correct answer.

Question 9 – Response C

Candidates knew that statement 3 was correct but chose the wrong alternative.

Question 12 – Response C

Candidates did not realise that bond breaking requires energy. This response was more popular than the correct one.

Question 14 – Response A

Candidates confused oxidising agent with the substance being oxidised.

Question 19 – Response C

Candidates did not realise that the zinc sulfate was in solution.

Question 26 – Responses B, C and D

All responses had an approximately equal numbers of candidates choosing them, suggesting that a high proportion of candidates were guessing the answer.

Question 36 – Response A

Candidates recognised the word gasoline but did not know what bitumen was.

Question 38 – Response A

Candidates selected the incorrect process for the conversion of ethene into ethanol.

Question 40 – Responses A, C and D

All responses had an approximately equal numbers of candidates choosing them, suggesting that a high proportion of candidates were guessing the answer.

CHEMISTRY (US)

Paper 0439/31
Theory (Core)

Key messages

- Many candidates need more practice in reading the question carefully to understand exactly what is being asked.
- Further practice is advised in answering questions about organic chemistry, especially the fractional distillation of petroleum and cracking hydrocarbons.

General comments

Many candidates tackled this Question Paper well, showing a good knowledge of chemistry. The standard of English was generally good. Some of the questions were left unanswered by some candidates.

Some candidates need more practice in reading questions carefully and noting the key words. For example, in **Question 2(c)** many candidates did not give the symbols of the atoms; in **Question 3(c)** many candidates did not read that the substance required was an acidic gas; in **Question 6(c)** some candidates did not read the key word ‘bonding’; and in **Question 8(d)** many candidates gave a property rather than a use.

Some candidates need more practice in answering questions requiring extended writing such as **Question 2(b)** (comparing the atmospheres of two planets); **Question 6(a)** (petroleum fractionation); and **Question 7(a)** (diffusion). Candidates should be encouraged to structure their answers logically and avoid writing contradictory statements.

Questions requiring the extraction of information from graphs and tables were generally well done; some candidates need further practice at dealing with negative numbers.

Many candidates need more practice in memorising definitions that appear in the syllabus, such as *element* and *isotopes*. Many candidates also need to revise qualitative tests, especially the chemical test for water.

Many candidates were able to balance symbol equations and undertake simple calculations; other candidates need to revise these areas.

Comments on specific questions

Question 1

(a) (i) Most candidates identified bromine as being diatomic. The commonest error was to suggest **D** (ethene).

(ii) Many candidates identified the ionic compound correctly. The commonest error was to suggest **C** (BrF_3).

(iii) Some candidates identified ethene correctly. Other candidates suggested BrF_3 and a significant number of candidates gave Br_2, despite this being the test reagent.

(iv) Some candidates realised that an ionic compound conducts electricity when molten. A wide variety of incorrect answers were given; the commonest being **D** (ethene) or **E** (dibromoethane).

(v) Many candidates gave the incorrect answer **B** (sodium bromide). Another common error was to suggest **E**, which contains only one type of halogen atom.

(b) A few candidates were able to explain the meaning of the term *element* but many answers were imprecise. The essential words which were often missing were 'only one type of atom'. There were many vague statements referring to the Periodic Table or 'a single atom' being present. The best answers often described 'a substance that cannot be broken down further by chemical means'. Few candidates referred to substances containing atoms each with the same number of protons.

(c) Many candidates realised that at –15°C bromine is a solid. Fewer candidates were able to explain this in terms of –15°C being below the melting point. Many candidates referred to boiling point of bromine. Many candidates had difficulty dealing with the negative numbers.

Question 2

(a) Most candidates calculated the percentage of methane in the atmosphere of Neptune correctly.

(b) Some candidates gave answers that just repeated the values in the table without reference to the percentage of gases on the Earth. Other candidates gave information which was vague or irrelevant. Where percentages of gases in the Earth's atmosphere were quoted, they were not always correct. A common error was to suggest that the Earth's atmosphere has 75% nitrogen.

Many candidates suggested that there is a considerable proportion of hydrogen in the Earth's atmosphere, typically in the range10–30%. Other candidates made comments about carbon dioxide, which were incorrect or could not be substantiated.

(c) Many candidates did not respond to the instruction to include the symbols for the atoms present. Common errors included the addition of further non-bonding electrons; Me in the central atom instead of C; three electrons in each of the overlap areas; or a lack of a pair of electrons in one of the overlap areas. A considerable number of candidates did not respond to this question.

(d) (i) Very few candidates gave a suitable definition of the term *isotopes*. Although many candidates appreciated that there is a variation in the number of neutrons, the commonest error was to omit the essential term *atom*. Many candidates just referred to 'elements' or 'molecules'. Other candidates wrote vague statements such as 'different ways to express the same atom'.

(ii) Many candidates deduced the number of protons and neutrons correctly. The commonest errors were to suggest one neutron, two protons or give three of each.

(e) (i) Most candidates were able to calculate the relative molecular mass of ethane. The commonest errors arose from the use of atomic numbers instead of relative atomic masses.

(ii) Very few candidates gave a correct chemical test for water. The commonest error was to refer to boiling point, melting point or density. Many of those candidates, who identified copper(II) sulfate as a test reagent did not mention 'anhydrous' or 'white' and did not give the correct result. A significant number of candidates did not seem to know the test given in the syllabus and suggested adding potassium or sodium to see if it bubbled; this was not accepted. Many candidates muddled the test with other test reagents, such as bromine or litmus.

Question 3

(a) (i) Many candidates were able to balance the equation. The commonest errors were $2H_2O$ and $4H_2O$. A few candidates added extra symbols, such as C.

(ii) Many candidates drew the structure of ethene instead of ethanol; added double bonds; or drew divalent hydrogen atoms, e.g. C–H–O. Many candidates did not include the O–H bond. A considerable number of candidates did not respond to this question.

(b) (i) The majority of candidates recognised pH 10 as being alkaline. The commonest errors were to suggest either pH 6 or pH 3.

(ii) Few candidates knew the correct colour change of methyl orange. Incorrect colours included orange, green, brown, purple and colourless. It should also be noted that the colour change expected is not for the mixed indicator screened methyl orange.

(iii) A correct word equation was given by many candidates.

(c) A small number of candidates recognised that sulfur dioxide is used a preservative for foods. Many candidates appeared not to have read the information in the question about the preservative being an acidic gas. Common incorrect answers included oxygen, nitrogen (which prevents oxidation rather than kills bacteria), hydrochloric acid, methane and sodium chloride. A considerable number of candidates did not respond to this question.

(d) (i) Some candidates omitted the word 'chromatography' or 'filter' for the paper, **P**. Other candidates suggested that the floor cleaner had been placed in the solvent **Q**.

(ii) Many candidates gave the correct answer. The commonest incorrect answers were 'titration', 'distillation' or 'colour separation'.

(iii) A majority of the candidates placed the cross on the baseline. Other candidates placed the cross just off the baseline or on the bottom of the paper. A significant number of candidates placed the cross halfway up the paper or near the top of the paper.

Question 4

(a) Some candidates understood that both potassium and graphite conduct electricity. Most other candidates suggested that only one of these species conducts; the most common error was stating that molten potassium does not conduct.

(b) Some candidates recognised that the low boiling point of iodine points to iodine being a simple covalent substance. The commonest incorrect answer was to refer to solid iodine not conducting electricity.

(c) A minority of the candidates recognised that zinc chloride is likely to be ionic because it *only* conducts when molten. The commonest incorrect answers referred to boiling points or density.

(d) Some candidates identified the electrode products correctly. Other candidates gave the correct products but at the incorrect electrodes. The commonest incorrect answer was to write chloride instead of chlorine. Other common incorrect answers included hydrogen or oxygen (at either electrode) or to write incorrect equations for the reactions at the electrodes.

A minority of the candidates wrote answers that related to chemical properties and not to electrode products. A considerable number of candidates did not respond to this question.

(e) Few candidates compared the reactivity of the chlorine and iodide. The commonest errors were to relate the reactivity of one of the elements to potassium or to hydrogen or to compare the reactivity of the halide ions rather than the halogens. A large proportion of the answers referred to the ease of mixing or referred to species that were not present. A considerable number of candidates did not respond to this question.

Question 5

(a) (i) A majority of the candidates balanced the equation correctly. The commonest errors were to suggest $4Cl_2$ or 1C.

(ii) The best answers suggested addition of oxygen to carbon. There were many vague answers relating to the titanium oxide, the titanium chloride or the carbon monoxide, rather than the carbon.

(b) Some candidates made the distinction between the physical properties of titanium and sodium; many candidates referred to general properties of metals and tried to make comparisons of electrical conduction or lustre. Other candidates referred to chemical properties including the formation of coloured compounds by titanium.

A considerable proportion of the candidates muddled the properties of transition elements and Group I elements. They suggested, for example, that sodium is very dense or that titanium has a low melting point.

(c) (i) Many candidates deduced a suitable melting point for potassium. Few candidates gave a suitable comment about the relative reactivity of lithium with water. The commonest error was to repeat the observations about sodium or to write that 'bubbles are formed' without any idea of the reaction being slower.

(ii) Some candidates described the general trend in density in terms of it increasing down the group. Other candidates either did not refer to the positions of the elements in the group or suggested that the density decreased.

(d) Many candidates realised that lithium forms a basic oxide; few candidates explained this is terms of lithium being a metal. Common errors included 'lithium is not an acid', 'lithium reacts with water to form an alkaline solution' and 'turns red litmus blue'.

Question 6

(a) Many candidates wrote vague or contradictory statements about the fractional distillation of petroleum. The commonest errors were to suggest that the distillation column is hotter at the top than at the bottom and that the vapours move down the column from the top or the middle.

The idea of vaporisation of the petroleum was generally given. Very few candidates mentioned the condensation of fractions. Other candidates mentioned boiling points but the idea of different fractions having different boiling points was rarely expressed with the required precision. A significant number of candidates did not respond to this question.

(b) (i) Some candidates realised that cracking involved the breakdown of hydrocarbons or molecules but many candidates did not gain credit because they wrote about other substances or even elements decomposing. A few candidates mentioned the use of high temperatures or the breakdown into smaller hydrocarbons. Other candidates disadvantaged themselves by suggesting that alkenes were broken down into alkanes.

(ii) Many candidates realised that gas **X** was hydrogen. The commonest error was to suggest carbon dioxide.

(c) A minority of the candidates identified the bonding as covalent. A significant number suggested ionic or gave answers that did not involve bonding, e.g. compound, saturated, hydrocarbon.

(d) Most candidates recognised the word 'polymer'. The commonest error was to suggest 'gas'.

Question 7

(a) Some candidates explained diffusion in terms of the kinetic particle model. Other candidates did not refer to particles and just suggested that the bromine or the cyclohexane moved. Many candidates did not include the word diffusion in their answers and wrote vague or incorrect statements.

(b) (i) A minority of the candidates wrote the correct molecular formula. Other candidates did not count the atoms correctly and gave formulae such as $C_4H_5O_2Br_2$.

(ii) Some candidates gave the correct name for the COOH functional group. A common error was to call this group an alcohol. Some candidates gave the name of a compound rather than the functional group, e.g. ethanoic acid.

(c) Many candidates selected two correct words from the list to complete the definition of relative atomic mass; few candidates selected all four correct words. The commonest errors were total (instead of average); molecule (instead of atom); and carbon or six (instead of twelve).

(d) (i) 'Increase the temperature' and 'use a catalyst' were the commonest correct marking points seen. Candidates who wrote about changing concentrations or changing the particle size of the magnesium often were often not specific enough to gain credit.

(ii) Most candidates balanced the equation correctly. The commonest error was to try to balance with 2HBr.

Question 8

(a) (i) The majority of candidates recognised the symbol for a reversible reaction. The commonest errors were to suggest that the symbol only referred to the backward reaction or to write vague statements such as 'it applies to both sides of the equation'.

(ii) Most candidates described the purpose of a catalyst correctly. The commonest error was to suggest that a catalyst is needed 'to make a reaction happen'.

(b) (i) Many candidates described how the yield of ammonia varies as the temperature increases. The commonest error was to omit a statement about whether the temperature was increasing or decreasing. A significant minority of candidates suggested that the yield increases with increasing temperature.

(ii) Most candidates gave a correct value for the yield at 400°C. The commonest errors were to suggest 29%, 48% or 24%.

(c) The calculation was well done by the majority of the candidates. Common errors were 134 or errors arising from dividing 20 by 140. A minority of candidates did not respond to this question.

(d) Some candidates gave a suitable use of nylon. Clothing, ropes and nets were the commonest correct answers. The commonest incorrect answer was the unqualified 'bags'. A significant number of candidates gave properties such as 'impermeable', rather than a use.

CHEMISTRY (US)

Paper 0439/41
Theory (Extended)

Key messages

When a question asks for observations, the answer should be something that can be seen. Hence 'gas made' or 'copper formed' are **not** observations, they are conclusions. The appropriate observations would be 'effervescence' and 'brown solid formed' respectively. Vague observations such as 'there is a colour change' do not gain credit; the colour change should be specified.

When the required conditions for a process are asked for, numerical answers for temperature or pressure should have units. Responses such as 'optimum temperature and pressure' are not creditworthy because they give no indication of what the optima are.

When a chemical equation is asked for, this means a balanced equation using correct symbols/formula and not a word equation.

General comments

Most candidates completed the entire paper in the allocated time and attempted all of the questions.

Candidates must read questions carefully to ensure they address in their answers all that is asked in the questions.

Working should be shown for calculations and this working should be set out clearly. This allows 'method marks' to be awarded in calculations, even if the final answer is incorrect.

Comments on specific questions

Question 1

(a) (i) The vast majority of candidates were able to identify **B** as having an atomic number of 12. The most common errors were to select **A**, presumably by adding the number of electrons to the number of protons, or **E**, which had 12 neutrons.

(ii) The majority of answers were correct, although a significant number of candidates opted for **C**, which has 14 neutrons rather than 14 nucleons.

(iii) This proved to be the most demanding part of **Question 1(a)**, with some candidates giving multiple answers. The most common error was to select **D**, which had more electrons than protons. This means that while **D** was an ion, it would have had a negative charge, rather than a positive charge.

(iv) This was very well answered and almost all candidates gained credit.

(b) The majority of candidates correctly identified **D** as an ion formed from oxygen, although a significant number of candidates ignored the instruction to write the formula **D**. Some candidates thought that **D** was neon.

Question 2

(a) (i) Most candidates realised that the particles would have the most energy at the highest temperature. The most common error was to select **Z**, which was the lowest temperature.

(ii) The vast majority of candidates answered this correctly.

(iii) Most candidates answered this correctly; **X** and **Y** were common errors.

(b) The majority of candidates realised the left-hand horizontal section of the graph represented freezing; many candidates read the graph carelessly and gave answers of 150 °C or below the minimum accepted temperature of 130 °C. Some candidates ignored the data provided and guessed a temperature that was not covered by the range on the graph.

(c) The term *sublimation* was known by the majority of candidates.

(d) (i) Most candidates could not recall the term *Brownian motion*; the most common incorrect answer was 'diffusion'.

(ii) This area of the syllabus was not very well understood by candidates, many of whom thought that smoke was a gas, rather than a colloidal suspension of a solid in air, meaning that the particles just move randomly. The correct explanation that many much smaller molecules in the air move randomly and collide with the smoke particles, resulting in them moving, was seen very rarely.

Question 3

(a) (i) Most candidates gave an answer which, while true, was not something that could be observed and so was not creditworthy. A common example of this was 'magnesium loses electrons', which is something that you cannot see.

(ii) The fact that a redox reaction is one that involves both oxidation and reduction was well known.

(iii) The most common error was to identify copper as the oxidising agent. The oxidising agent must be on the left-hand side of the equation and so could only be Mg or Cu^{2+}. Some candidates were able to go on to say what an oxidising agent does in the reaction given.

(iv) Many candidates were unable to write the formula of iron(III) oxide correctly and so were unable to score credit. A significant number of candidates did not balance the equation and made the iron produced diatomic.

(b) (i) Many candidates scored credit by stating the paint prevents oxygen and water from making contact with the iron.

(ii) Many candidates could correctly explain why magnesium prevented rusting; common errors included stating the magnesium acted as a barrier or that the magnesium rusted.

(iii) A comparison of the reactivity of copper and iron was required. Some vague answers were seen, such as 'copper is unreactive' as well as some incorrect ones, such as 'copper is a transition element and so will rust'.

Question 4

(a) (i) Most candidates were able to give carbon dioxide as a product and go onto write a balanced equation. A common error was to have water as a product.

(ii) Vague answers were seen, such as 'warm'. A number of improbable temperatures and pressures were seen, presumably due to candidates getting fermentation confused with other industrial process on the syllabus.

(b) (i) The catalyst was known by very few candidates; 'iron' was a very common error.

(ii) Many fully correct answers were seen; answers showing no working were common. Working should always be shown, as it may be possible to award method marks even if the final answer is incorrect.

(c) (i) Only a small minority of candidates could state the name of a suitable oxidising agent.

(ii) Many candidates answered this question correctly; a common error was to show all bonding electrons correctly but to omit the non-bonding electrons on the oxygen atoms.

(d) (i) Only a small minority of candidates could explain the meaning of the term *weak* in reference to an acid. The most common incorrect answers stated weak acids have a higher pH than strong acids; this is incorrect as a very dilute strong acid may have a higher pH than a much more concentrated weak acid. Candidates are expected to know that weak acids are only partially dissociated in aqueous solution.

(ii) Almost all candidates omitted to state that the two acids used should be of the same concentration. Many answers gave a suitable test/reagent; some of these did not then state how the results would show that ethanoic acid was weaker than hydrochloric acid.

(e) A small number of fully correct answers were seen. Common errors included missing off the hydrogen joined to the oxygen atom in either structure or showing the –OH group of the alcohol as bonded to the carbon via the H atom (O–H–C). The name of the alcohol, butan-1-ol was rarely correct.

Question 5

(a) (i) The colours of copper(II) carbonate and copper(II) oxide were known by only a very small minority of candidates.

(ii) Many candidates could not write the correct formula of copper(II) carbonate. Some of those candidates who did still did not gain credit because they gave oxygen as a product.

(b) (i) The qualitative test for copper(II) ions was better known than that for nitrate ions. Fully correct answers were not common. The addition of an acid rather than sodium hydroxide was common in the nitrate test.

(ii) Many fully correct answers were seen.

(c) (i) This proved to be a very demanding question for many candidates. Only a minority of candidates were able to state that the colour would become paler and then explain this in terms of the equilibrium moving to the right because there were fewer moles of gas on the right.

(ii) Candidates found this a demanding question. Only a minority of candidates were able to link the colour change to the position of equilibrium moving to the right. A common incorrect explanation was to say the equilibrium moved to the exothermic side. There is no exothermic (or endothermic) *side* in any reaction; there is an exothermic and an endothermic *direction.*

Question 6

(a) Some candidates were able to state that aluminium is more reactive than carbon. A significant number of candidates incorrectly stated that the aluminium oxide would react with the carbon to make either carbon dioxide or aluminium carbonate.

(b) (i) Many fully correct answers were seen, although it was common to show the oxide ion with eight dots in the outer shell rather than six dots (representing the electrons from derived from oxygen) and two crosses (representing the electrons derived from aluminium).

(ii) Many answers contained contradictory statements, such as ‘ionic bonding’ followed by comments about attractive forces between atoms or molecules, rather than between ions.

(c) (i) The particles responsible for the conduction of electricity were not well known.

(ii) Very few candidates gave two correct reasons why cryolite is used. Common errors were claiming that it changed the melting or boiling point of aluminium, or implying that it acted as a coolant and so reduced the temperature, rather than lowering the operating temperature.

(iii) Many fully correct answers were seen although errors in the charge of the aluminium ion were also common.

(iv) Very few candidates were able to give a full and logical explanation as to why carbon dioxide is produced. The most commonly missing point was the one concerning oxygen being made at the anode; most answers just talked about oxygen from the aluminium oxide and so did not score this marking point. It was not uncommon for candidates to claim that the carbon came from the cryolite, rather than from the anode.

(d) Only a minority of candidates knew that aluminium was coated with a layer of aluminium oxide. Most answers gave incorrect explanation based either on the low reactivity of aluminium or the fact that the acid was not concentrated.

Question 7

(a) (i) The majority of answers just stated that there would be more particles of acid rather than more particles per unit volume. Many candidates correctly talked about collision frequency rather than there just being more collisions.

(ii) The majority of candidates stated that the particles would have more energy or would move faster; very few candidates went on to state that more of the particles now had energy greater than the activation energy or that a greater proportion of collisions would be successful.

(b) (i) Many fully correct answers were seen; answers showing no working were common. Candidates should always include the working in their numerical answers, so that method marks can be awarded where possible.

(ii) The most common error in this solution based calculation was not to convert the volume of hydrochloric acid from cm^3 to dm^3.

(iii) Very few candidates completed this last step of the calculation.

(c) Many fully correct answers were seen. A common error was to miss out the first step of calculating the number of moles of each element and instead go straight to dividing each by the smallest; this will give the simplest ratio of percentage composition by mass and not the simplest ratio of moles, which is required to deduce an empirical formula.