CHEMISTRY (US)

Paper 0439/21
Multiple Choice (Extended)

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

General comments

Candidates performed well on this paper.

Candidates found **Questions 3**, **4** and **29** the most straightforward.

Questions 21 and **25** were the most challenging for candidates.

Comments on specific questions

Question 7

Response **B**: Candidates did not account for the information given about the melting point and electrical conductivity of solid X.

Question 8

Response **B**: Candidates did not take account of the fact that benzene is a liquid at room temperature and pressure. Response **B** was more popular than the correct one.

Question 12

Response **B**: Candidates knew that the reaction was exothermic but did not correctly account for the temperature change.

Question 13

Response **B**: Candidates did not fully understand the processes of bond breaking and formation.

Question 21

Response **A**: This response was more popular than the correct response. Candidates seemed confused by having to interpret equations. All responses had a significant number of candidates choosing them.

Question 25

Responses **B** and **C**: There was some confusion between the formation of iron in the blast furnace and the production of steel.

Question 26

Response **A**: Candidates placed the metals in the reverse order.

Question 34

Response **A**: Candidates perhaps confused burning limestone with heating limestone to produce lime.

CHEMISTRY (US)

Paper 0439/31
Paper 31 Theory

Key Messages

- Many candidates need more practice in questions involving qualitative analysis.
- Many candidates need further practice in answering questions involving a range of chemical reactions, especially when extended answers are involved.
- Interpretation of data from tables was generally well done.

General comments

Many candidates showed a good knowledge of core Chemistry. The standard of English was generally good. Several sections were left unanswered by some candidates, especially Questions **3(d)**, **4(a)**, **6(a)** and **7(e)(iii)**.

Some candidates need more practice in reading questions carefully and noting key words. For example, in Question **4(a)** many candidates did not refer to particles and in Question **5(c)(i)** many did not take notice of the phrase "apart from conducting electricity".

Many candidates need more practice in answering extended questions such as Question **3(d)** manufacture of lime by thermal decomposition of limestone, Question **4(a)** particle theory related to diffusion and Question **6(a)** reactions of acids. Candidates should be encouraged to organise their work and take note of all the reactions asked for in the question. Other candidates need practice in answering questions relating to extraction of information from graphs and tables.

Many candidates need more practice in memorising definitions that appear in the syllabus, such as relative atomic mass and isotopes. Many also need to revise qualitative tests especially flame tests and the test for chlorine.

Many candidates were able to balance chemical equations and some candidates were able to do simple calculations. Other candidates need to revise these areas.

Questions involving chemistry such as atomic structure, properties of materials and the uses of selected elements and compounds were well tackled well by some candidates. Other candidates need more practice in these areas as well as in writing organic structures.

Comments on specific questions

Question 1

(a) (i) This was almost invariably correct. The commonest error was to suggest helium rather than hydrogen, despite the fact that helium did not appear in the table.

(ii) Few candidates identified hydrogen being released at the cathode. The commonest incorrect answers included metals such as lithium, sodium, potassium and copper which were not present in the electrolyte.

(iii) Very few candidates identified sulfur. A wide variety of incorrect answers were seen, including both metals and non-metals.

(iv) Few candidates identified calcium. The commonest incorrect answers were zinc and aluminium whose precipitates dissolve in excess aqueous sodium hydroxide.

(v) Some candidates realised that aluminium is extracted from bauxite. The commonest errors were to suggest copper or potassium.

(b) (i) Some candidates were able to explain the meaning of the term isotope but few mentioned atoms. Many answers were imprecise. For example, the unqualified statement "same number of protons and different number of neutrons" does not refer to elements or atoms. It could refer to molecules. Similarly, "elements with different numbers of neutrons" could apply to different elements.

(ii) Many candidates calculated the number of neutrons correctly. The commonest error was to suggest a proton number of 80.

(iii) Nearly all candidates gave the correct answer for the number of protons. A few suggested the mass number of 124.

(iv) Many candidates calculated the number of electrons correctly. The commonest errors were either to add two electrons to the proton number, giving the incorrect answer of 82, or to refer to the charge on the mercury ion, giving an incorrect answer of 2.

Question 2

(a) (i) Many candidates described two differences in the ionic composition of water samples **A** and **B** by focusing on individual ions. Others made basic errors in comparing the concentration of chloride ions or potassium ions incorrectly. Some candidates made generalisations that were not true. For example, "all the positive ions in sample **A** have a higher concentration than sample **B**". Others made comparisons within each sample. For example, "**A** has high chloride and sodium concentration compared with the other ions".

(ii) Nearly all candidates selected the correct ion, magnesium.

(iii) Some candidates calculated the mass of sodium ions and correctly showed full working. Common incorrect answers included: 0.2 mg (often because 1 dm^3 was taken to be 10 000 cm^3); 2000 mg or 50 mg.

(b) A minority of candidates knew the flame test to identify sodium ions. Those who did understand that a flame test was required generally got the correct colour. A few suggested red or lilac. The commonest error was to suggest testing the reactivity with water, presumably through reading the stem of the question as sodium metal rather than sodium ions. Other common errors included electrolysis, adding sodium hydroxide or adding litmus.

(c) Some candidates realised that the movement described was Brownian motion. The commonest incorrect answers were "diffusion" or "vibration".

(d) (i) Nearly all the candidates recognised the symbol for a reversible reaction. The commonest errors involved imprecise writing, for example, "the reaction is both sides".

(ii) Many candidates suggested the addition of indicator to the solution under test. Few candidates suggested a comparison with a colour chart or the idea of different colours representing different pH values. Many incorrect answers either referred to one or more specific colours without reference to pH or gave imprecise statements such as "if it's in the acid, it will turn orange".

(iii) Some candidates realised that carbon dioxide is responsible for climate change. Others gave imprecise answers such as the unqualified "increases the temperature" or "makes the Earth hotter", rather than "makes the atmosphere hotter".

(iv) Many candidates identified a suitable greenhouse gas although some suggested nitrogen or hydrogen. The commonest correct answers referred to methane together with a correct source. A few candidates gave vague or incorrect sources such as "fossil fuels" or "farms".

Question 3

(a) Some candidates drew correct and clear diagrams to show the electronic structure of a calcium atom. Others did not appear to know that the first electron shell contains two electrons. Common errors included: four electrons in the outer shell; first shell with eight electrons; and the outer shell with eight or more electrons.

(b) The commonest error for this question was to reverse the anode and cathode.

(c) The equation was generally completed correctly. The commonest errors were H or 2H on the right (rather than H_2) or O_2 or non-completion of the equation on the right.

(d) A small number of candidates gave answers that included the idea of thermal decomposition of limestone and the relevant equation. Most other candidates did not appear to know the thermal decomposition reaction but gave suitable uses of lime. Incorrect and vague statements were often written, many unrelated to the question. Many candidates did not respond to this question.

Question 4

(a) Some candidates explained diffusion in terms of the kinetic particle theory. Others did not refer to particles and just suggested that the chlorine or the gas moved. Many candidates did not include the word diffusion in their answers and wrote vague or incorrect statements. Some candidates wrote about chlorine moving or the gas spreading out but did not refer to particles or molecules. A significant number of candidates did not respond to this question.

(b) (i) Many candidates identified a correct use of ^{235}U in terms of energy production or nuclear power stations. Many answers were too vague, for example, "industries", "nuclear use" or "medicine".

(ii) Many candidates gave a correct answer referring to cancer. Others gave answers which were far too vague. A small number of candidates gave an industrial use rather than a medical use.

(iii) The definition of relative atomic mass was not known by the majority of the candidates. Hardly any candidates mentioned either averages or comparison with ^{12}C. The commonest incorrect answers were "the total sum of the protons and neutrons" or "the total mass of the element".

(c) (i) Most candidates completed the equation correctly. The commonest error was to write $2Cl$ instead of Cl_2.

(ii) Some candidates gave a use of chlorine in terms of disinfecting swimming pools, bleaching or in water treatment. Other candidates wrote statements that were not specific enough such as "for cleaning" or "to make an acid".

(iii) Some candidates linked the acidic oxide, Cl_2O_7, to the position of chlorine in the Periodic Table or to the non-metallic nature of chlorine. Other candidates gave incorrect answers relating to the acidity of chlorine or its oxide or tried to make a link to oxygen. Many candidates suggested that Cl_2O_7 is a basic oxide, often suggesting that this is because "it has no hydrogen ions".

(iv) Few candidates knew the test for chlorine. The commonest error was to suggest that litmus would turn red. A significant number of candidates thought that the litmus would turn blue.

Question 5

(a) (i) Nearly all candidates related the increase in strength to the increased percentage of carbon. Very few candidates suggested an inverse relationship.

(ii) The best answers were given by candidates who suggested that there was no relationship between the percentage of carbon and its average melting point or melting range. Those who referred to melting points alone often did not perform well because they did not imply that it was the average melting point. Those candidates who specified a melting range were often more successful.

(iii) Most candidates chose steel **D** and specified resistance to corrosion. A few candidates specified corrosion but omitted to write the letter **D**. The commonest incorrect answer referred to steel **B**. Candidates who stated steel **A** needed to state clearly that it was the strongest rather than just strong: all the steels are strong; the key point is that **A** is the strongest.

(b) Many candidates chose **A** as the diagram best representing an alloy. The commonest incorrect answer was to choose **B** in which there is complete regularity in the layers of iron, chromium and nickel, which would be impossible in a bulk manufactured alloy.

(c) (i) Some candidates gave good answers based on the strength of the steel core. Others gave incorrect answers which referred to malleability, magnetism, giving protection against corrosion. A significant number of candidates referred to electrical conduction despite the fact that the stem of the question stated “apart from conducting electricity”.

(ii) This part was well answered by the majority of candidates. Some answers were too vague. Better performing candidates generally referred to aircraft and linked this to low density.

(d) (i) Many candidates gave vague answers and referred to iron rather than aluminium, for example, “iron because oxygen is taken”. Better performing candidates referred to aluminium gaining oxygen.

(ii) Many candidates thought that the reaction was endothermic even though they stated that the reactant energy level is above the product energy level. Those who correctly stated that the reaction was exothermic often wrote imprecise statements such as “because it goes up and down”.

Question 6

(a) Most candidates did not appear to know about the reactions of acids with metals, bases and carbonates. The better performing candidates organised their work carefully giving answers to each of the reactions in turn. Candidates most commonly wrote about the effect on litmus and about the production of hydrogen when an acid reacts with a metal.

(b) (i) This was almost invariably correct. Very few candidates suggested that density increases as the number of carbon atoms increases.

(ii) Many candidates gave a value of the boiling point of pentanoic acid within the accepted range. The commonest errors were to give a value lower than 170 °C or to give a range that was not totally within the range required, for example, 160–180 °C.

(iii) Many candidates deduced that ethanoic acid is a solid at 15 °C but fewer candidates gave the reason. It is not sufficient to refer to the value of the melting point alone. Reference should be made to the melting point being above 15 °C. A considerable number of candidates gave a reason without giving the state or gave the correct state without giving a reason.

(iv) Few candidates gave the correct structure of the carboxylic acid group. Common errors included omission of an O atom or incorrect placement of hydrogen (C–H=O). Some candidates gave hydrocarbon structures.

(v) Many candidates calculated the relative molecular mass correctly. One common error was to use one or more atomic numbers instead of atomic masses with the calcium often being incorrect but the oxygen and carbon correct. Another error was not multiplying the atomic mass of oxygen by 3. Sometimes it was multiplied by 2.

(c) Many answered this correctly. The commonest error was to suggest that salt dissolving in water is a chemical change.

Question 7

(a) A majority of the candidates identified melting and boiling correctly. The commonest error was to suggest "condensing" for either **A** or, more rarely, for **B**.

(b) Many candidates could describe the motion of the particles, but not both the motion and the arrangement. Common incorrect statements regarding the arrangement of the particles were: "far apart", "move freely" or "no definite shape".

(c) Few candidates knew the uses of sulfur. The commonest correct answer was "to make sulfuric acid". Common incorrect answers included "disinfectants", "neutralising acids" or vague statements such as "fuel", "solvent" or "industries".

(d) Candidates who identified sulfur dioxide often gave a correct effect on health. Others gave answers without reference to sulfur dioxide such as "it harms the eyes". There were a considerable number of imprecise answers such as "dangerous to humans" or "bad for health".

(e) (i) Many candidates deduced the correct formula. Common errors included CH_4S, $H_4 + C_4 + S$, C_6H_4S or a partial structural formula such as $C_2H_2SC_2H_2$.

(ii) Most candidates recognised that a catalyst speeds up the rate of a reaction.

(iii) The better performing candidates tended to calculate the mass of thiophene correctly. Common errors included 15.6 × 2.6 = 40.56 or 15.6 + 1.6 = 17.2, with the 1.6 arising from 4.2 – 2.6. A considerable number of candidates did not respond to this question.

CHEMISTRY (US)

Paper 0439/41
Theory (Extended)

Key messages

When answering a question that involves a calculation, candidates should show their working. This enables the examiner to follow a candidate's working, even if the final answer is incorrect.

For a material to be an electrical conductor, it must contain changed particles that are able to move throughout the structure. The ideas of being "able to move throughout the structure" cannot be replaced by the word "free".

Candidates should know the formula of compounds that are on the syllabus, such as ammonia.

General comments

Some excellent responses were seen to all questions on the paper.

Question **4(b)** and Question **8(b)** proved demanding for candidates. These dealt with equilibria and kinetics respectively.

Comments on specific questions

Question 1

(a) This was generally well answered, although **J** was a common incorrect answer, despite **J** being identified as a metal in **(f)**.

(b) This was generally well answered, although **J** was a common incorrect answer.

(c) Most candidates were able to identify a suitable method of separation.

(d) The majority of candidates realised that to separate two liquids the process of fractional distillation would be required. A few candidates opted for "simple distillation" or just "distillation". Some candidates were not familiar with this part of the syllabus, with "crystallisation" being a common wrong answer.

(e) Some fully detailed descriptions of an appropriate method of separation were given by better performing candidates. Some candidates focussed on obtaining substance **G** rather than substance **H** and these candidates would have benefitted from reading the question carefully. A few candidates used the terms "filtrate" and "residue" but got them the wrong way round. It is important to use technical terminology correctly. It was not uncommon for candidates to attempt separation by distillation, given that the lowest boiling point component of the mixture boiled at 1413 °C, this is not a reasonable method to use.

(f) Many candidates identified that the conductivity of metals was something to do with electrons. Others were unable to state that the electrons could move throughout the structure. It was common to see responses that stated the electrons were "free" or "delocalised"; neither of these statements state that the electrons can move. Many organic compounds that are not conductors of electricity have delocalised electrons and it is not clear what a "free" electron is.

Question 2

(a) Most candidates answered **(i)** and **(iii)** correctly. In **(ii)**, the term "sublimation" was less well known.

(b) Many candidates incorrectly focussed on the need to provide energy for the particles to move faster rather than the need to overcome attractive forces or bonds between particles.

(c) Almost all candidates could correctly state that the pressure was higher in container **E**; many candidates could not explain why. Many candidates focussed on collisions between particles rather than between particles and the walls of the container. A small number of candidates thought that the particles in **E** would move faster.

Question 3

(a) In **(i)**, the majority of candidates knew that the petroleum needed to be heated before it entered the fractionating column. A significant number of candidates thought that filtration was required. In **(ii)**, a significant number of candidates did not read the question carefully and so rather than give two ways in which fraction **O** differed from fraction **L**, they gave two different uses for the fractions.

(b) This question on the characteristics of a homologous series proved to be straightforward for some candidates, but many candidates gave vague answers, such as "they have similar properties". Some candidates did not read the question carefully and rather than give characteristics of a homologous series they gave specific characteristics of alkanes.

(c) Some candidates drew the same structure twice but with a different conformation. Other common errors were divalent hydrogen atoms and tri- or penta-valent carbon atoms.

(d) This was well answered by the better performing candidates. Other candidates often left this question blank or produced impossible structures.

(e) Part **(i)** was very well answered but the empirical formula calculation in **(ii)** proved to be demanding to candidates. Many of the candidates who made progress with the question by dividing by the A_r and then simplifying to get the ratio of 1:1.6, then either rounded the ratio to 1:1.5 (giving the formula C_2H_3) or rounded to 1:2 (giving the formula CH_2). It should be remembered that the data used for an empirical formula calculation will be derived theoretically and so there should never be any need to round as per the examples given. Many candidates struggled with the calculation in **(iii)**.

Question 4

(a) In **(i)**, many candidates did not know that both hydrogen and nitrogen are diatomic elements or that ammonia is NH_3. In **(ii)**, many candidates knew that nitrogen came from the air. Some candidates also thought that hydrogen came from the air. The temperature of the Haber process in **(iii)** was better known than the pressure. As well as incorrect pressures, there were errors in the units of pressure.

(b) Many candidates stated that at equilibrium the concentrations of reactants and products were equal, which is not true; they are constant but they are very unlikely to be equal to each other. Despite the instruction in **(ii)**, it was evident that many candidates did not use the graph provided and so did not realise that as temperature increased, so did the yield of ammonia. For **(iii)**, a significant number of responses focussed on rate rather than yield and so stated that a higher pressure gave a faster rate and so a greater yield. Better performing candidates either used the graph or worked out from the equation provided that an increase in pressure decreased the yield. They then explained this in terms of the number of moles of gas on each side of the equation.

Question 5

(a) This was not well known. Only a minority of candidates knew that the gas formed at the anode would be oxygen; hydrogen was a very common error. Of those candidates who did identify the gas as oxygen, many could not describe the simple laboratory test. Answers which were clearly contradictory were common, such as testing the gas with a lighted splint with the expected result being that the splint would light. It should be noted that testing a gas with a flame is not a "flame test".

(b) This was not well known. The most common error was to state that the conductivity of the solution was due to electrons rather than ions. It should be noted that "free" is not taken to mean "able to move".

(c) The majority of candidates could explain that reduction was the gain of electrons in part **(i)**; relatively few candidates could identify copper(II) ions as the species being reduced. Most candidates stated copper or simply "the cathode".

While the majority of candidates could predict how the masses of the electrodes would change in **(ii)**, some candidates just stated that they would change or commented on the size rather than the mass changes. It was not uncommon for candidates to attempt to explain the mass changes in terms of the gain or loss of electrons rather than the gain or loss of copper from the electrode.

Part **(iii)** was only answered well by the better performing candidates. These candidates explained that copper(II) ions are both removed and added to the solution at that same rate. Many attributed the colour to the sulfate ions rather than the copper(II) ions.

Question 6

(a) Many candidates could correctly describe a polymer as being a large molecule made from many smaller molecules called monomers.

(b) Better performing candidates could name the amide or peptide linkage in proteins. The meaning of "biodegradable" was less well known, with many responses suggesting that it meant that it was "kind to the environment" or "did not pollute" rather than it was something that was broken down naturally by microbes. The example of another natural polymer in **(iii)** caused many candidates problems. A common error was to give "carbohydrates" as the answer. Some carbohydrates, such as starch, are natural polymers but others, such as glucose, are not polymers.

(c) Some excellent answers were seen to this question. However, many candidates drew structures with di- or trivalent hydrogen or di- or tetravalent nitrogen.

Question 7

(a) Many candidates answered the calculation correctly. Better performing candidates included clear working out in their responses. A common error was to convert the volume given in cm^3 to a volume in dm^3 incorrectly.

(b) Many candidates realised they had to use the stoichiometric ratio from the equation provided and simply divide the number of moles of HCl by two. However, presumably because the word "gas" was used in the question, some candidates used the number 24 somewhere in their calculation.

(c) Better performing candidates clearly showed the steps in their calculations, including the calculation of the M_r of carbon dioxide and then correctly multiplying this figure by the number of moles of carbon dioxide.

(d) Better performing candidates were able to calculate the volume of carbon dioxide, while others did not seem to know what to do. Some candidates who had used the value of "24" in their calculations for **(b)** did not use it here.

Question 8

(a) In **(i)**, many candidates did not read the question carefully and described how the volume of carbon dioxide changed rather than the rate of reaction. Candidates who did describe how the rate of reaction changed often did not explain why the rate of reaction changed. Those candidates who tried to explain why the reaction stopped, often stated that the reactants were used up or the magnesium carbonate was used up, despite the fact that the question stated there was an excess of magnesium carbonate.

Part **(ii)**, was the best answered part of Question **8.** Most candidates could correctly predict that the initial rate of reaction would increase due to a larger surface area of solid. The lack of change in the total volume of gas collected was less well explained; responses were often not based on the number of moles of reactant used.

(b) Many candidates did not read the question carefully. The question asked for an explanation of why the rate of reaction of magnesium with hydrochloric acid increased over the first two minutes. Instead, many candidates tried to explain why magnesium reacted more quickly than magnesium carbonate. Better performing candidates answered this question well, stating there would be an increase in temperature and then linking this to why the reaction speeds up.