CHEMISTRY (US)

Paper 0439/11
Multiple Choice

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

Candidates performed well on this paper. Questions **1**, **2**, **3** and **25** proved to be the most straightforward, with a high proportion of candidates selecting the correct response.

Questions **5**, **11**, **14**, **17**, **19**, **20**, **22**, **27**, **30**, **35** and **40** were the most difficult for candidates.

The following responses were common incorrect responses to the questions listed:

Questions 5

Response **B**. Candidates clearly knew that hydrogen atoms have no neutrons but failed to spot that the question was asking about the nucleus, not the whole atom.

Questions 11

Response **C**. Candidates realised that the reaction was endothermic but not that carbonates neutralise acids.

Questions 14

Responses **A** and **B**. There was clearly some confusion concerning the colour changes of cobalt(II) chloride when water is removed and added.

Questions 17

Response **C**. Candidates knew that **B** and **D** were base properties but were not sure of the other reactions of bases.

Questions 19

Response **C**. Candidates were confused about changes in the reactivity of Group VII elements, thinking that they varied in the same way as the reactivity of Group I elements.

Questions 20

Response **D**. Candidates knew what should go in the gap (1) but selected the first answer which fulfilled this criterion, rather that reading the whole question.

Questions 22

Response **C**. Candidates did not realise that not all group 0 elements have eight electrons in their outer shells.

Questions 27

Candidates found this question difficult. All responses were popular, indicating a degree of guessing by candidates.

Questions 30

Candidates found this question difficult. All responses were popular, indicating a degree of guessing by candidates.

Questions 35

Response **C**. The main reason for this error was candidates misreading the word ‘ethane’.

Questions 40

Response **B**. Candidates knew about cracking but failed to identify the correct effect of aqueous bromine on hydrocarbon Q.

CHEMISTRY (US)

Paper 0439/21
Core Theory

Key Messages

- Many candidates need more practice in answering questions relating the structure and bonding of compounds to their uses.
- Greater specificity is required in answers in many cases. This is particularly true for questions involving the extraction of information from graphs and those involving kinetic particle theory.
- Some candidates need more practice in questions about organic chemistry, especially drawing structures of organic molecules.

General comments

Many candidates tackled this Core Theory Paper well, showing a good knowledge of Chemistry. Some of the questions were left unanswered by a minority of candidates, particularly **Question 4(b)(ii)**, **Question 5(c)** and **(d),** and **Question 6(b)**, **(c)** and **(e)**.

Some candidates need more practice in memorising simple chemical tests, e.g. the test for unsaturation with aqueous bromine, and in memorising definitions, e.g. the definition of a hydrocarbon.

Most candidates need further practice in questions requiring extended answers, in particular, the inclusion and organisation of specific details (which could be in bullet point form). Some candidates need further practice in using the Periodic Table to answer questions about atomic structure.

Many candidates were able to extract relevant information from tables and balance symbol equations. Others need practice in calculating relative formula masses and identifying particular types of organic compound.

Comments on specific questions

Question 1

(a) In part **(i)**, many candidates identified barium chloride for the sulfate test. Part **(ii)** was generally well done with the commonest error being to suggest **F**. Part **(iii)** was almost invariably correct. Fewer candidates could identify H–C*l* as being acidic in part **(iv)**, the commonest errors being to suggest methane or barium chloride. Part **(v)** was less well done. There was no consistent incorrect answer. In part **(vi)**, most candidates realised that methane is the main component of natural gas. A common error was to suggest water.

(b) (i) Many candidates placed the arrow for heating in a suitable position. Common errors included heating the connection between the tubes; heating the top of the tube; and heating the aluminium chloride.

(ii) Many candidates suggested a suitable safety precaution. Those who did not gain credit generally wrote statements which were too vague. Very few mentioned the use of a fume cupboard.

(iii) Most candidates balanced the equation correctly.

Question 2

(a) Many candidates gave a suitable answer with most referring to the ease of dissolving or to ensure an even temperature distribution. Those candidates who did not gain credit often made comments referring to a chemical reaction.

(b) Most candidates gave at least one factor which should be kept the same. Common incorrect answers usually referred to the temperature of the room or the pressure.

(c) (i) Most candidates identified **Q** correctly. There was no consistently incorrect answer.

(ii) Nearly all candidates identified the endothermic changes. Those candidates who did not score the mark generally chose a mixture of endothermic and exothermic changes.

(d) (i) Most candidates recognised that ^{235}U is radioactive. The commonest incorrect answer was to choose ^{1}H.

(ii) Some candidates deduced the number of neutrons correctly. Others gave the proton number or the nucleon number.

(iii) Some candidates gave a suitable use of radioactive isotopes in medicine. Others did not read the words “in medicine” in the question and gave industrial uses.

(e) (i) A majority of the candidates recognised that kerosene is used as a fuel for jet aircraft. There were no consistent incorrect answers.

(ii) Most candidates balanced the equation correctly. Some candidates omitted this question.

Question 3

(a) Most candidates wrote “CO_2” as the correct product and balanced the equation correctly. Common errors included “C” and “O_2” as products.

(b) (i) Nearly all candidates completed the diagram correctly. The commonest error was to reverse the anode and cathode.

(ii) Some candidates correctly deduced that nickel is formed at the cathode. Other suggested that nickel is formed at the anode or at the graphite electrode.

(c) (i) Some candidates correctly recognised that nickel is formed at the cathode and chlorine at the anode. Other candidates suggested hydrogen or oxygen is formed at the anode or suggested chloride. A considerable number of candidates did not respond to this part of the question.

(ii) Many candidates realised that graphite conducts electricity. Fewer candidates realised that graphite does not react with the electrolyte and gave answers relating to other properties of graphite.

(d) (i) Few candidates could relate the structure and bonding of diamond to its properties. Common errors included the idea that the bonds were hard. Some candidates wrote about the structure of diamond as being “tetrahedral” or wrote that “there are lots of atoms”.

(ii) Few candidates could relate the structure and bonding of graphite to its use as a lubricant. A minority of candidates mentioned the layered structure. Those who mentioned sliding often just suggested that “the atoms slide” without further details. The commonest error was to suggest that the atoms themselves are slippery.

Question 4

(a)(i) Many candidates referred to the gradient of the graph or the relative time taken to complete the reaction. Other candidates just referred to the relative position of strontium and calcium in Group II of the Periodic Table.

(ii) Most candidates deduced the volume of gas produced correctly.

(iii) The majority of the candidates gave a suitable time for the completion of the reaction. The commonest error was to suggest 68–70 seconds.

(iv) Many candidates referred to the line for calcium not reaching the final volume. Other candidates gave rather vague answers which did not refer to the graph.

(v) Many candidates realised that smaller pieces of calcium have a larger surface area. Some candidates did not gain credit because they did not refer to the change in the rate of reaction.

(b) (i) Some candidates realised that a measuring implement with sufficient accuracy had to be used to deliver the strontium hydroxide solution. Other candidates incorrectly suggested using glassware with poor accuracy such as measuring cylinders or beakers.

(ii) Some candidates recognised the role of litmus as an indicator. Few candidates described the colour change of the litmus and some candidates gave an incorrect colour change. Many candidates did not respond to this part of the question.

(c) (i) There were many vague answers to this question. Many candidates did not refer to the pH values or volumes. Other candidates just concentrated on the drop in pH. Better-performing candidates mentioned a large drop in pH when 30 cm^3 of hydrochloric acid had been added and that the pH then decreased gradually. Very few candidates wrote about the slow decrease in pH at the beginning of the titration.

(ii) Many candidates gave the correct volume of acid. Others misread the graph and gave values between 30 cm^3 and 35 cm^3.

(iii) Many candidates named the salt correctly as strontium chloride. Common errors were to suggest strontium oxide or strontium hydroxide.

Question 5

(a) Few candidates scored full credit for this question. Many candidates scored some credit for comparing the movement of the particles in the solid and liquid. Many candidates incorrectly thought that the particles in the liquid were relatively far apart. A considerable number of candidates did not mention particles or molecules and just wrote about water and ice or the bulk properties of these.

(b) Most candidates gave a suitable use for water in the home and in industry. Some gave the same use for both.

(c) (i) The word equation was not always correctly written, with a few candidates not including the addition signs or the arrow. Common errors were water instead of hydrogen and lithium oxide instead of lithium hydroxide.

(ii) Few candidates gave suitable observations for the reaction of lithium with water. The commonest error was to suggest that lithium bursts into flames or explodes. Few candidates mentioned bubbles or floating on the surface. Many candidates did not give observations and wrote about lithium being less (or more) reactive than sodium or wrote vague statements such as “gives off a gas”.

(iii) Some candidates realised that potassium is more reactive than lithium. Other candidates thought that because they were in the same group of the Periodic Table, the two metals had a similar reactivity. A considerable minority suggested that lithium is more reactive than potassium.

(d) (i) A minority of the candidates drew the correct structure of ethanol. Common errors included: drawing the structure of methane or ethane; the inclusion of a double bond; and drawing the hydrogen of the OH group in the incorrect place, i.e. C–H–O.

(ii) Some candidates suggested, correctly, that heat or high temperature is required to make ethanol from ethene. Few candidates gave a second condition. The commonest errors were to suggest room temperature or the presence of carbon dioxide.

(e) Some candidates placed the metals in the correct order of reactivity. Calcium and cobalt were the metals most often placed incorrectly.

Question 6

(a) Many candidates were able to deduce the molecular formula of isoprene. The commonest error was to attempt to write a condensed structural formula.

(b) A minority of candidates recognised the test for unsaturated compounds using aqueous bromine. Few candidates gave the correct result with the main error being to suggest that the colour did not change. Other errors commonly seen were to suggest that the compound should be burnt (without any suggestion of the smokiness of the flame) or that ethanol should be added.

(c) (i) Some candidates related addition polymerisation to the presence of a double bond in the monomer. Other candidates gave answers which were insufficient or irrelevant such as just giving the name of a polymer or just writing “monomer”.

(ii) The name of an addition polymer was rarely seen. Most candidates preferred to name a monomer such as ethene or propene.

(d) Some candidates were able to explain the lack of conductivity of isoprene in terms of its simple molecular structure. Others gave a suitable, but less accurate answer in terms of it not having a metallic structure. Common errors included “it is not reactive” and “it has got a double bond”.

(e) Some candidates gave the correct products of incomplete combustion. Other candidates suggested carbon dioxide or hydrogen. A considerable minority gave incorrect products which included elements which were not in the reactants, e.g. nitrogen, oxides of nitrogen or nitrates.

(f) Many candidates identified the –ol suffix of the alcohols correctly. The commonest error was to suggest that the compound was a carboxylic acid.

Question 7

(a) Many candidates gave a good description of the numbers and charges of protons, neutrons and electrons in sodium. Some candidates concentrated on the electronic structure and did not appear to use the Periodic Table to help them. Common errors included: protons in shells; electrons in the nucleus; numbers of protons and electrons reversed; and no mention of the position of the subatomic particles. A considerable number of candidates did not respond to this part of the question.

(b) (i) A majority of the candidates balanced the equation correctly.

(ii) Some candidates gave a suitable definition of the term *hydrocarbon*. Other candidates omitted the essential word “only” or gave examples of hydrocarbons.

(iii) A minority of the candidates calculated the relative formula mass of sodium carbide correctly. Other candidates used atomic numbers or multiplied the values incorrectly.

CHEMISTRY (US)

Paper 0439/31
Extended Theory

Key messages

Answers should always address what has been asked in a question. For example, if a question asks about rate of reaction, then marks will not be gained by giving answers that deal solely with equilibria or some other aspect of chemistry.

Chemical equations should be balanced symbol equations unless the question specifically asks for a word equation. If a word equation is asked for then a symbol equation should **not** be given as the answer.

When the position of an equilibrium moves, it can move either to the right or to the left; it cannot move either up or down.

General comments

There was no evidence that candidates ran out of time with all scripts seen showing answers attempted throughout the paper. Some very high scoring scripts were seen and excellent answers were seen to all questions on the paper.

Question 2 proved demanding as it required recall of chemical properties and then application to state and explain a suitable separation technique.

Comments on specific questions

Question 1

(a) Parts **(i)** and **(ii)** proved to be more demanding than parts **(iii)** and **(iv)**, which were commonly correct. A common error in **(ii)** was to give Kr, presumably through candidates not reading the question carefully and just giving the name of another noble gas.

(b) In part **(i)** there were many fully correct answers, but it was common for candidates to miss the “2+” charge on the copper and so give an incorrect value for the number of electrons.

In part **(ii)** there were errors due to a confusion between “nucleons” and “neutrons” and also due to candidates forgetting that there would be an equal number of electrons and protons.

(c) Part **(i)** was very well answered, although some candidates gave only part of an answer, for example commenting on mass number but ignoring atomic number. It should be stressed that relative atomic mass is the mean mass allowing for isotopic abundance and so is not a suitable term to use when explaining what isotopes are.

Most candidates identified magnesium in part **(ii)**.

A wide variety of uses of radioactive isotopes were seen in part **(iii)** although a common error was to state that radioactive isotopes are used in chemotherapy; they are not, they are used in cancer treatment by *radio*therapy.

Question 2

(a) Many answers seen were based on spurious differences between copper and zinc, such as solubility or particle size. Some impractical methods, such as fractional distillation, or vague

answers, such as “find a solvent which will dissolve only one of them” were seen. Only a minority of candidates recalled that, of the two elements, only the zinc would react with a dilute acid, and so adding excess dilute acid and then filtering would yield the copper.

(b) The two most common creditworthy answers seen were based either on fractional distillation (although many candidates did not mention liquefying the two gases first) or reacting something with the oxygen and leaving the nitrogen (although many candidates did not identify a substance that would produce a gaseous oxide and so enable separation).

(c) The reference in the question to R_f values enabled many candidates to select chromatography as a suitable method.

(d) This was the most poorly answered of the four parts in **Question 2**. Incorrect answers based on fractional distillation were as common as correct answers based on the amphoteric nature of zinc hydroxide. However, some candidates showed an excellent chemical knowledge and gave clear and fully correct answers.

Question 3

(a) Many candidates gave fully correct answers, some even went on to give (unnecessary) explanations of why the rate would be faster. However, some candidates were clearly unsure of how to answer this question and claimed that the use of a spray prevents the production of pollutants, despite the required product being sulfur dioxide.

(b) This question proved difficult for candidates. Candidates were expected to recall that air is 20–21% oxygen and apply this to the question. Some candidates gave implausible answers less than 1 dm^3.

(c) While a minority of answers just repeated what was in the question by stating that air is cheaper, many candidates realised that excess air would either move the equilibrium to the right and so use up most or more of the sulfur dioxide. Many candidates gave only half the required answer.

(d) In part **(i)** there were some excellent answers, although some candidates did not explicitly say what would happen to the position of equilibrium. It should be noted that a reaction does not have an endothermic (or exothermic) *side*; it is either the reverse or forward *reaction* that is exothermic (or endothermic).

Despite part **(ii)** asking about rate, many candidates gave answers based on equilibrium. The required answer had to be comparative, i.e. “slow*er*” rather than just “slow”. Full credit could not be awarded without some idea of particles or molecules as the explanation required was based on collision theory.

(e) In part **(i)**, some answers just said the equilibrium moves to the side with fewer moles without explicitly stating which side that was.

Part **(ii)** was well answered.

(f) The most common error was to omit the oxidation state of the vanadium or to state the catalyst used in the Haber process.

(g) There were some very confused answers which involved reducing sulfur trioxide back to sulfur dioxide or involved further reactions with oxygen and hydrogen. Some candidates gave full descriptions of the process starting from sulfur and air. However, there were some excellent answers that not only stated the two stages of the process (react with concentrated sulfuric and then with water) but also gave explanations (which were not required) as to why the sulfur trioxide could not be reacted directly with water.

Question 4

(a) In part **(a)(i)** there was some confusion as to the problems caused by the disposal of synthetic polymers in landfill sites. While many fully correct answers were seen, many answers were contradictory, for example claiming that the polymers do not break down (which is correct) but then stating that they will give off toxic compounds (contradicting the first point). Many answers were too vague to gain credit such as “pollution” or “environmental problem”.

In part **(a)(ii)** there were again some vague answers, such as “air pollution”, which were not credited.

(b) The most common errors were either for candidates to name synthetic polymers (rather than give a use) or to state they were used to make plastics (which is not a use since plastic is a generic term which covers all synthetic polymers).

(c) While many completely correct answers were seen to part **(i)**, many structures omitted the C=C double bond that is essential in the monomer of an addition polymer. Some candidates gave the repeat unit of the polymer, which is not what had been asked for.

The functional group in part **(ii)** proved challenging for some candidates. The most common error was to say that it was an acid group. Those candidates who gained credit in part **(ii)** often also gained credit in part **(iii)**; other candidates seemed just to guess the names of two functional groups.

(d) While some excellent and well-structured answers were seen, many candidates seemed to start their answers with little idea of where they were going, and then ended up contradicting themselves. Candidates need to check they have answered all that is asked for in questions. It was not uncommon for candidates to miss the requirement to classify **A** and **B** or just to describe one of the two types of polymer.

Question 5

(a) Part **(i)** was almost always correct.

In part **(ii)**, answers were almost always completely correct or totally wrong. Only a small minority of candidates were able to work out the mole ratio of the elements but then not able to deduce a correct formula.

Part **(iii)**, proved very difficult for many candidates; they needed to make use of their previous answer and the data in the question. Many molecular formulae seen would clearly not have had an M_r of 86.

(b) In part **(i)**, the use of bromine water as a test for the presence of a C=C double bond was well known. However, candidates were often not aware that it is not a test for *any* double bond, such as C=O.

The production of hydrogen as an indication that the substance was acidic in part **(ii)** was less well known.

Part **(iii)** required use of the answers to parts **(b)(i)** and **(ii)** as well as the M_r given in part **(a)(iii)**. This was a demanding question. Candidates are reminded that any proposed structural formula should be plausible in terms of bonding and valency.

Question 6

(a) Some excellent answers to part **(a)(i)** were seen, although this area of the course was clearly not well known by some candidates. Poor answers referred to layers or even carbon atoms in the structure of silicon(IV) oxide.

Many candidates gave completely correct answers to part **(ii)**.

Part **(iii)** proved much more demanding. The most common error was to use an indicator of some sort; since silicon(IV) oxide has a macromolecular structure it is insoluble in water and so will not change the colour of an acid-alkali indicator.

(b) While a minority of candidates correctly stated that carbon dioxide has a simple molecular structure, many simply stated that carbon dioxide is a gas. Since the difference in boiling point is a physical property for which the candidates were expected to give an explanation, simply stating that that one is a gas does not answer the question.

Question 7

(a) Many candidates did not read the question in part **(i)** and just stated which step was reduction but offered no explanation. Some candidates stated that **step 1** was reduction but then stated that it showed the gain of electrons (which although a correct definition of reduction, was not shown in **step 1**).

In part **(ii)** there was also evidence of candidates not reading the question; some candidates gave no explanation and some gave the step and not the ion. There was careless use of terminology with claims that the silver ion (which is Ag^+ and not just Ag) oxidised brom*ine* or *Br*, rather than oxidising brom*ide*.

(b) Some excellent answers to this question were seen, giving clear descriptions of the colours that would be seen and a reason based on the photochemical reaction. However, many candidates failed to use the information in the question regarding the colour of the silver produced or focused on a reaction between the paper and the sunlight rather than of the silver bromide.

(c) Many correct answers were seen to part **(i)**, although some candidates mixed up the reagents and products.

Part **(ii)** was well answered. The most common error was to state that chloroplasts were the substance responsible for the colour in green plants.

The structure of the polysaccharide in part **(iii)** proved very demanding. Very few candidates gained full credit and many candidates failed to show the correct linkage between glucose units. Bridging hydrogen atoms was a very common error. Many of those who did correctly link together two glucose units failed to gain the second mark by drawing a disaccharide (terminal –OH groups) rather than a continuing polymer chain.

While there were some good answers to part **(iv)**, many candidates failed to link the process to a release of energy by reaction with oxygen or to the involvement of a biological system. The most common error was to confuse respiration with gaseous exchange.