CHEMISTRY (US)

Paper 0439/11
Multiple Choice

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

Candidates performed well on this paper. **Questions 1**, **3**, **5**, **9**, **10**, **15**, **19**, **22**, **27** and **30** proved to be the most straightforward with a high proportion of candidates selecting the correct response.

Questions 13, **20**, **21**, **23**, **25**, **32** and **36** were the most difficult for candidates.

The following were common incorrect responses to the questions listed:

Question 13

Response **A**. Candidates did not read the alternative statement (2) carefully and so thought it to be correct.

Question 20

Response **B**. Candidates correctly selected elements “W” and “X” but did not identify that “Y” would also form a basic oxide because it is a transition metal.

Question 21

Response **D**. Candidates did not realise that copper would not react with the two acids.

Question 23

Response **D**. Candidates did not identify that hydroxides, not oxides, are formed when Group I metals react with water.

Question 25

Response **C**. Candidates correctly identified the structure of an inert gas but did not realise that the question specifically referred to helium.

Question 32

Responses **A**, **C** and **D**. This question was not well answered and all responses had a significant number of candidates opting for them.

Question 36

Response **C**. The difference between ethane and ethene was not taken into account correctly.

CHEMISTRY (US)

Paper 0439/21
Core Theory

Key Messages

- Some candidates would benefit from more practice answering questions requiring extended answers especially those about the reaction of acids with metals and metal oxides, acid-base titrations and diffusion.
- Many candidates would benefit from more practice at answering questions on specific tests for ions and unsaturated compounds.
- Candidates should be reminded to read the stem of the question carefully and not repeat or paraphrase the stem as well as to take note of phrases such as 'one other use'.

General comments

Some candidates tackled this Paper well, showing a good knowledge of core Chemistry. The standard of English was generally good. Nearly all candidates were entered at the appropriate level. And responses were seen to all the questions.

The extraction of information from tables of data was generally fairly well done. Many candidates did less well when extracting information from graphs.

As in previous sessions, quantitative tests were not well known.

In organic chemistry, some candidates could answer simple questions about carbon compounds but fewer could identify the OH functional group of alcohols or write the formula of ethanol showing all atoms and bonds.

Many candidates would have benefitted from more revision of practical procedures such as chromatography, acid-base titrations and comparing the energy released when different fuels are burned.

Some candidates performed well on questions involving free response. Others would benefit from more practice in answering this type of question in terms of remembering basic chemical facts and organising their ideas.

Comments on specific questions

Question 1

This was the best answered question in the Paper. Some candidates scored well in **(a)**. Others scored only partial credit. Fewer were able to write the correct molecular formula in **(b)**. In **(c)** some candidates got full credit for balancing the equation. Many others did not score.

(a) Most candidates gave the correct answers to **(a)(i)** and **(a)(vi)**. In **(a)(ii)** a significant number of candidates chose the unsaturated hydrocarbon, B, instead of the saturated hydrocarbons A and D. A wide range of incorrect answers were seen in **(a)(iii)** and **(a)(iv)**. In **(a)(v)** many candidates suggested that compound C is a greenhouse gas. Although many compounds can act as greenhouse gases, release of methane into the atmosphere is far more important in terms of global warming than the other compounds given in the question.

(b) Some candidates were able to deduce the molecular formula of dibromoethane correctly. Others wrote the numbers of atoms in front of the symbols e.g. 2Br4H2C, sometimes with a plus sign between them. Other common errors were CH_4Br_2, $C_2H_2Br_2$ or writing the word 'bromine'.

(c) Some candidates balanced the equation correctly. The commonest error was to balance oxygen incorrectly, $3O_2$ often being seen. Other errors were to suggest 6 water molecules balance the oxygen and water in the correct ratio 10:8 but to forget to double the other species

Question 2

Many candidates recognised the correct ion in **(a)(i)**. Fewer were successful in gaining credit in the rest of **(a)**. Very few candidates knew the test for chloride ions in **(b)**. In **(c)** most candidates recognised that poly(ethene) is a polymer but few were able select the correct word for the second gap in the sentence.

(a) (i) Many candidates recognised that the sodium ion was present at the highest concentration. The commonest error was to suggest potassium ions. A significant minority suggested chloride ions.

(ii) Few candidates recognised the correct names for the fluoride and nitrate ions. The fluoride ion was usually called the fluorine ion and the nitrate ion was given a variety of names, the commonest incorrect ones being 'nitrogen oxide' or 'nitroxide'.

(iii) Some candidates were able to calculate the mass of sodium ions in 200 cm^3 of mineral water correctly. Others either gave values which were significantly different e.g. 198 or made simple errors in their calculations.

(iv) Many candidates did not refer to the pH value of 6.8 in the table and suggested 'neutral', possibly assuming that the water would be pure water. A significant minority of the candidates suggested that the pH would be 'strongly acidic'.

(b) Very few candidates knew the test for aqueous chloride ions. Most either suggested adding ammonia or sodium hydroxide. Others suggested electrolysis or adding litmus. A significant number of candidates did not respond to this question.

(c) Most candidates correctly identified poly(ethene) as a polymer but few were able select the correct word for the second gap in the sentence. The commonest error was to suggest 'saturated' instead of 'monomer'. A few candidates wrote monomer in the first gap and polymer in the second gap.

Question 3

This question was one of the least well done on the Paper. Many candidates could identify the alcohol functional group in **(a)** but few could give the correct test for an unsaturated compound in **(b)**. Few candidates scored more than minimal credit for **(c)** whilst in the chromatography question only the higher scoring candidates obtained credit in **(d)(ii)** and **(d)(iii)**.

(a) Many candidates identified the alcohol functional group correctly. Common errors included putting a circle around the CH_2-CH_2OH group or the C-OH group.

(b) Few candidates knew the test for an unsaturated compound using aqueous bromine. Many did not realise that a chemical test was required and wrote about heating, burning, diluting with water or using steam. Many candidates did not respond to this question.

(c) (i) A few candidates obtained credit for suggesting that maceration extracts the pigment or that the solvent dissolves the pigments. Others gave vague answers such as 'shows the colours', 'so that you can use chromatography' or 'so as to separate the pigment'.

(ii) A minority of the candidates realised that a lot of pigment would be absorbed onto the filter paper. Others gave vague answers such as 'so you can see the colour change', so there is no residue to separate' or 'because there is no need to filter'. Many candidates did not respond to this question.

(d) (i) Many candidates identified the procedure as chromatography. The commonest incorrect answer was 'filtration'. Other common incorrect answers included 'diffusion' or 'distillation'.

(ii) Some candidates placed the spot of pigment just above the solvent level. The commonest incorrect answer was to place the spot half in and half out of the solvent. A significant number of candidates placed the spot either below the solvent level or near the top of the paper.

(iii) Few candidates realised that the solvent might evaporate or that the atmosphere in th be saturated with solvent vapour. Some candidates gave vague answers such as 'so the experiment doesn't get contaminated' or 'so the solution (rather than the solvent) doesn't ge significant number of candidates suggested that there might be a reaction between the air and solvent or the spots.

(iv) Many candidates gave identified the spots correctly. Others gave only A or C as the answer rather than both. A significant number of candidates chose D.

(e) A few candidates drew the structure of ethanol correctly showing all atoms and all bonds. Others drew the structures of ethene, ethane or other hydrocarbons. Other common errors included joining a hydrogen to the carbon atom (C – H – O) or missing out hydrogen atoms altogether.

Question 4

Many candidates gave good answers to **(a)**, **(e)** and **(f)(iii)**. Fewer could describe in **(c)** why the water in the can needs to be stirred. Others wrote too vague a definition of an alloy in **(f)(i)** and could not explain why tin prevents the steel from rusting in **(f)(ii)**.

(a) Many candidates realised that the thermometer was the essential piece of apparatus missing from the diagram. The commonest answer which was not accepted was 'stirrer'.

(b) Many candidates suggested one factor which should be kept the same in the experiment. Few suggested two correct factors. Others gave vague statements relating to 'the same solvents', the 'same room temperature' or 'the same top pan balance'.

(c) Few candidates could describe why the water in the can needs to be stirred. Common incorrect answers included 'to speed up the reaction', 'so the reaction can occur' or 'to make the molecules attract each other'.

(d) Many candidates realised that the mass of the burner would decrease. Few gained the second mark for the idea that on combustion, gases were formed. The commonest error was to suggest that the liquid evaporated. Others suggested that the mass decrease was due to the 'energy given out' or 'the product being used'.

(e) Many candidates calculated the greatest temperature change correctly. The commonest error was to suggest G, which had the highest final temperature but a relatively high starting temperature.

(f) (i) A minority of the candidates gave a suitable definition of an alloy. Many did not gain credit because they suggested that an alloy is a compound or referred to the properties of an alloy rather than its structure.

(ii) Few candidates gave a satisfactory explanation why tin prevent steel from rusting. Many candidates just paraphrased the stem of the question by writing statements such as 'it protects the steel from rusting'. Few candidates referred to a layer covering the steel. Many suggested that tin rusts. Others referred to irrelevant properties such as thermal conductivity or strength. A significant proportion of the candidates did not respond to this question.

(iii) Many candidates identified silicon dioxide as a giant covalent structure. The commonest error was to suggest a giant ionic structure.

Question 5

Some candidates could describe the reaction of acids with metals and metal oxides in sufficient detail to obtain full credit in **(a)**. Others appeared not to have learnt this section of the syllabus. A greater number of candidates could identify an exothermic reaction in **(b)**. Many candidates were able to deduce the number of protons, neutrons and electrons in two isotopes of uranium in **(d)**. In **(c)**, fewer could give a use of a radioactive isotope which did not involve the production of energy.

(a) Many candidates did not respond to this question. A minority of candidates obtained more than half the available credit. Others wrote vague statements such as 'acids corrode the metal'. Many did not read the stem of the question properly and gave neither word equations nor the names of specific acids, metals or metal oxides.

(b) Some candidates could identify an exothermic reaction from the temperature change. Th commonest error was to suggest 'endothermic'.

(c) A minority of candidates gave a suitable use of radioactive isotopes not involving energy production. Many did not read the stem of the question carefully enough and suggested 'nuclear fuels' or 'nuclear bombs'. Others gave the names of radioactive elements such as plutonium or neptunium.

(d) Many candidates deduced the number of protons, neutrons and electrons in the two isotopes of uranium correctly. The commonest error was to suggest 235 and 238 electrons. A minority of the candidates suggested 92 neutrons in both isotopes.

Question 6

Some candidates scored well on this question, especially in **(a)(i)**, **(a)(iii)** and **(a)(v)** (all relating to rate of reaction). Many did not score well in **(a)(iv)** (graphical interpretation of reaction rate) or **(b)** (carrying out a titration).

(a) (i) Many candidates obtained partial credit for this question. A significant number of candidates did not refer to the horizontal part of the curve where the concentration remained constant and so did not obtain full credit.

(ii) Some candidates deduced the time taken for the concentration of sodium hydroxide to fall to 0.15 mol/dm^3 correctly. Others gave inaccurate values, 3 minutes 45 seconds and 3 minutes 50 seconds being common errors. Some did not do the calculation properly and gave an approximate value of 4 hours.

(iii) Many candidates deduced the time correctly. Others gave values which were far too low e.g. 8 hrs 25 minutes or far too high e.g. 12 hours.

(iv) Few candidates obtained full credit for drawing the line when the concentration of bromobutane is increased. Common errors included: drawing a line parallel to the original line; drawing a line starting at zero and levelling off at about 0.2 mol/dm^3 or drawing a line above the original.

(v) Many candidates identified one other correct method of increasing the rate of reaction. The commonest errors were to suggest increase in pressure or changing the temperature (instead of increasing the temperature).

(b) Few candidates knew the procedure for an acid-base titration. Credit was most often given for the careful addition of acid to alkali. Many candidates ignored the burette and suggested that the titration be carried out in the volumetric pipette. Few mentioned the use of the indicator. Those did often placed the indicator in the burette or pipette. A considerable number of candidates did not respond to this question.

(c) A minority of the candidates drew the electronic structure of hydrogen chloride completely correctly. Others either added extra non-bonding electrons to the hydrogen or drew an ionic structure not showing the hydrogen atom. A small number of candidates drew the structure as H_2Cl or H_4Cl.

Question 7

This question was the least well done on the Paper. Some candidates gained credit for **(a)** (fertilisers) and two out of the three marks for **(f)** (electrolysis). Few candidates obtained credit in **(b)**, **(c)**, **(d)** and **(e)** (mainly inorganic chemistry).

(a) Some candidates gave correct answers relating to increase growth of crops. Others gave answers which were too vague e.g. 'to make crops healthy', 'to make soils better' or 'to give the earth more minerals'.

(b) Few candidates identified the reaction as neutralisation. The commonest errors were to suggest 'addition', 'displacement', 'exothermic' or 'endothermic'. Others gave answer which did not refer to types of reaction e.g. 'covalent'.

(c) Many candidates did not read the question properly and suggested 'ammonium sulfat commonest errors were to combine nitrogen compounds with sulfates e.g. sulfate of nitr 'sulfur nitrogen'.

(d) Few candidates deduced the correct simplest ratio of ammonium to sulfate ions. A common erro was to write sulfate 6: ammonium 12. A significant minority of the candidates did not count the ions correctly or reversed the ratio (1 ammonium to 2 sulfate).

(e) A minority of candidates obtained partial credit. Very few obtained full credit. Many candidates wrote vaguely about 'slaked lime removes the nitrogen' or 'nitrogen can be taken in'. Many just repeated the information given in the equation and wrote 'sodium sulfate is formed'. A significant number of candidates did not respond to this question.

(f) Some candidates obtained full credit. Others did not identify the anode or cathode and wrote potassium and chlorine in both columns or gave the substance that the anode and cathode could be made from (graphite). Many candidates gave chloride instead of chlorine at the anode. Others gave chlorine at the cathode and potassium at the anode.

Question 8

A few candidates performed well on this question. Many candidates used the information in the table in **(b)(i)** to predict the state of astatine. Others did not score many marks because they did not understand the process of diffusion in **(a)** or give convincing arguments in **(b)(ii)** or gave the incorrect formula for astatine in **(b)(iii)**.

(a) Some candidates explained the process of diffusion well. Others did not use the word diffusion or could not explain it in terms of movement of particles. The credit given most often was for the idea of iodine crystals dissolving in the solvent. A significant number of candidates did not respond to this question.

(b) (i) Many candidates suggested that astatine should be solid at room temperature. The commonest error was not to use the trend in the table and suggest gas or liquid.

(ii) Many candidates repeated information in the stem of the table e.g. 'heat is given off by astatine'. The few candidates who suggested that the heat or energy was sufficient to melt the solid gained the mark. Many wrote vague statements such as 'because of the heat' or 'because of the melting point'.

(iii) The commonest error was not to recognise that the halogens are diatomic molecules. Most wrote 2At or At in the space in the right. Many candidates ignored astatine and wrote I or I_2 in the space on the right.

CHEMISTRY (US)

Paper 0439/31
Extended Theory

Key messages

Where a question asks for an equation the requirement is for a balanced symbol equation. Word equations are appropriate only when the question specifically asks for a word equation.

The halogens, nitrogen, oxygen and hydrogen all form diatomic molecules – hence they should be shown as such in equations (N_2 for example).

The terms ion, atom and molecule are not interchangeable

General comments

The majority of candidates completed all questions and there was no evidence that candidates were short of time.

Comments on specific questions

Question 1

(a) The majority of candidates obtained full credit on this question. A very small minority reversed the pH scale (so low numbers were alkaline) but still obtained credit for the pH of water.

(b) Very few candidates obtained full credit – but many obtained partial credit by stating that one of the acids was strong or fully ionised but not linking that to the concentration of hydrogen ions in the solution.

(c) Despite the question asking for a another method other than measuring the pH, a very large number of candidates suggested the use of universal indicator. Of those that selected to look at the rate of a reaction a significant number could not be credited as they were vague about the substance with which the acid was to be reacted – just stating “metal” is insufficient as some metals do not react with acids. A number of candidates suggested doing a titration – despite having already been told the acids were of the same concentration.

Question 2

(a) While some excellent answers were seen there were also many answers which indicated a very poor understanding of how the properties of graphite are related to its structure. The two most common errors were stating that the gaps between the layers left space for electricity to flow or that the bonds were weak so the atoms could move. It should be noted that to conduct electricity the electrons have to be free to move throughout the structure, electrons being delocalised does not mean a substance will conduct electricity – benzene has delocalised electrons yet benzene is a non-conductor.

(b) Most candidates correctly stated that graphite was used as lubricant or in pencils. However, many candidates were vague in the use they stated based on graphite’s electrical conductivity; simply stating “electrolysis” – this is insufficient since there are a number of components in an electrolysis circuit while only the electrodes can be made of graphite

(c) In **(c)(i)** a few clear descriptions of the structure of silicon(IV) oxide were seen, but many answers described structures with incorrect valencies for silicon or oxygen or, rather carelessly, described

structures containing carbon. In **(c)(ii)** many candidates were able to predict correctly properties of both silicon dioxide and graphite.

Question 3

(a) Despite the question asking for two uses other than making sulfuric acid, one of the most common answers was to state sulfur dioxide was used to make sulfuric acid. Other common errors included giving uses of sulfuric acid or an environmental problem caused by sulfur dioxide. Candidates must ensure they answer the question that has been asked rather than the question asked in a previous year or the question they wanted to be asked.

(b) Some very good answers were seen but again vague answers or ones that did not fully address the question were common. A surprising number of candidates thought electrolysis would be a suitable method.

(c) In **(c)(i)** only a minority of candidates could correctly state the formula of vanadium(V) oxide, many thought that the (V) indicated five vanadium atoms should be included in the formula. In **(c)(ii)** it was common to gain partial credit for a correct reference either to yield or energy – few candidates commented on both aspects. In **(c)(iii)** relatively few candidates gave correct explanations, although most could state that the yield and rate would be higher. It was a common misconception that increasing the pressure gave the particles more energy and there were many answers with contradictory statements regarding the position of the quilibrium – stating that the yield of sulfur trioxide increased and the position of equilibrium moved left. It should be noted that while there are fewer gaseous moles on the right of the equilibrium there are not fewer gaseous moles in the forward reaction.

(d) This was clearly not very well known or understood. Although some answers were correct, some thought that the problem was that the sulfur trioxide would not react or would make a product other than sulfuric acid.

Question 4

(a) In **(a)(i)** only a minority of candidates stated that there would be insufficient oxygen higher up in the Blast Furnace and so the carbon dioxide (formed lower down) would react with carbon. Many gave answers based on the relative densities of the gases – this cannot be a valid argument as there is a flow of gas through the furnace from the bottom (where hot air enters) to the top (where waste gases exit). Many of the equations seen in answer to **(a)(ii)** did not have iron as a product (although oxides of iron were commonly seen – despite the act that the Blast Furnace is used to obtain iron), a significant number who did have iron as a product failed to score as they had iron as being diatomic; equations are not balanced by changing formulae – the stoichiometric coefficients must be changed.

(b) Most candidates obtained credit in **(b)(i)** but in **(b)(ii)** many candidates gave an incorrect formula for silicon(IV) oxide. The majority of candidates obtained full credit in **(b)(iii)** but a number of odd reasons were given in **(b)(iv),** including a common error in thinking that molten iron was unreactive.

(c) Most candidates obtained credit in **(c)(i)** although a few thought that hydrogen was required. Many answers seen to **(c)(ii)** were very poor – candidates had not read the question carefully. The question stated that aluminium coated with aluminium oxide is protected from further corrosion, hence answers that just stated the aluminium oxide formed a protective coating were merely repeating the information in the question that they should have been explaining and so could not be credited.

(d) In **(d)(i)** the credit was awarded most commonly for stating that zinc is more reactive than iron. Many candidates obtained no further credit. Very few answers considered that when the zinc reacts it loses electrons and that these electrons flow through the wire to the steel and prevent the atoms in steel from losing electrons. A common error was to state that zinc rusts (only iron or steel can rust). It was very common in **(d)(ii)** to see arrows in the sea-water (the electrolyte) – electrons are responsible for the conduction of electricity only in metals and graphite, in aqueous solutions it is the movement of ions. Few correct equations were seen in **(d)(iii)**, only a minority of candidates gave hydrogen as being a diatomic molecule and many had the charge on the hydrogen ions wrong.

Question 5

(a) Most candidates cited the reaction between nitrogen and oxygen, but far fewer linked the re to the high temperatures in the engine. Some candidates incorrectly stated that the oxides of nitrogen were products of complete (or incomplete) combustion of the fuel.

(b) Some excellent and highly detailed answers were seen, the very best of which included correct equations for the reactions. Some candidates did not fully answer the question and did not consider all of the pollutants. A common misconception was that the catalytic converter acted as a filter and trapped the pollutant gases in some way.

(c) While many correct answers were seen, many candidates appeared to have guessed – resulting in lead compounds being blamed many environmental problems including global warming, acid rain and damaging the ozone layer. A common error was to state that they prevented the blood carrying oxygen – some confusion with carbon monoxide being evident.

Question 6

(a) In **(a)(i)** only a minority of candidates managed to name both of the acid and alcohol required, of those candidates that obtained partial credit more were able to name the alcohol than the acid. Most candidates were able to obtain partial credit for two of the first three points in **(a)(ii)**, a common error was to add together the moles of each reagent to determine the number of moles of product formed.

(b) Some excellent answers were seen, although many candidates seemed to have little idea of what an ester linkage was – despite one being shown in the structure towards the top of the page. Some candidates managed to correctly draw the ester link correctly, but did not realise that the monomer units needed to alternate or that being a polymer there needed to be an indication that the structure continued to each side.

(c) In **(c)(i)** many candidates scored well on this part although a significant number mixed up the results for saturated and unsaturated compounds or failed to state the starting colour of bromine somewhere in their answers. Most candidates who correctly identified “ester 1” were also able to explain why. It was common for candidates to score just partial credit in **(c)(iii)** with salt and alcohol being the common correct answers.

Question 7

(a) Part **(a)(i)** was poorly answered, the most common errors being incorrect formulae – monatomic nitrogen or triatomic lithium were often seen. While some excellent diagrams were seen in **(a)(ii)** candidates should be reminded that diagrams should be drawn large enough so that the “x” and “o” symbols can be seen clearly.

(b) Many fully correct diagrams were seen, the most common error being the omission of one or more of the non-bonding pairs of electrons.

(c) Many candidates incorrectly stated that covalent bonds were weak – they are not. Substances with simple molecular substances have relatively low melting/boiling points due to weak intermolecular forces. Some candidates referred to intermolecular forces in the ionic compound – this shows a clear lack of understanding between the types of particles involved in different structures.