CHEMISTRY

Paper 0971/22
Multiple Choice (Extended)

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

General comments

Candidates performed well on this paper.

Candidates found **Questions 1**, **3**, **4**, **9**, **14**, **26**, **28**, **30**, **32**, **36**, **38** and **40** to be of lower demand.

Comments on specific questions

The following responses were popular incorrect answers to the questions listed:

Question 7

Response **A** – Candidates chose the lowest number. This response was more popular than the correct one.

Question 11

Response **D** – Candidates knew the correct direction for the ions but did not look at the polarity of the power supply.

Question 16

Response **B** – Candidates were confused about the meaning of the term *oxidising agent*.

Question 19

Candidates found this question challenging. All responses were selected by a significant number of candidates, indicating that many were unsure of the correct answer.

Question 25

Response **C** – Candidates chose the wrong direction for the reactivity change.

Question 33

Response **C** – Candidates missed the word 'weak' when selecting this response. This response was more popular than the correct one.

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Paper 0971/42
Theory (Extended)

Key messages

- Candidates must ensure they read questions carefully to ensure that the answer they give addresses what has been asked. Responses seen in **Question 2(d)(i)**, where electron arrangements were omitted and in **Question 3(c)(ii)**, where descriptions of reactions rather than observations were given, were typical examples where candidates did not read the question fully.
- When drawing organic structures, candidates should be aware that structures require all bonds to be drawn and thus the valency of the atoms used need to be correct. Divalent hydrogen atoms and monovalent oxygen atoms were often seen.
- When a chemical equation is asked for, this means a balanced symbol equation using correct symbols/formulae and not a word equation.
- In questions where a stated number of responses is asked for, such as a single property, two (or three) properties should not be given as incorrect statements may contradict correct answers.
- In extended questions, such as **Question 4(c)**, candidates are advised to present their answers in short, sharp sentences, even using bullet points. Long, rambling sentences often lead to omission of some facts and contradiction of others.

General comments

Most candidates appeared to be well prepared for this paper.

Better performing candidates attempted to show full working in the two calculation questions; this is good examination practice.

Very few candidates felt the need to write on extra pages. If candidates do need to write on extra pages the question they are answering must be clearly labelled.

Comments on specific questions

Question 1

(a) (i) Most candidates found this question straightforward and could name the changes of physical states. Sublimation proved the most difficult of the four terms for candidates to recall.

(ii) Most candidates were able to express a coherent answer to this straightforward question.

(iii) The temperature at which the processes take place was the expected answer. Most candidates were able to give a difference between boiling and evaporation by simply thinking about the processes. e.g. evaporation is a surface process; boiling has bubbles.

(b) Candidates who performed less well thought ‘separation’ required the name of a separation process, such as filtration or chromatography.

(c) Candidates knew the formula of a typical Group I oxide, whether expressed as X_2O or through use of an actual formula such as Li_2O. A relatively large proportion did not balance the correct species, whilst candidates who performed less well opted for $X_2 + O \rightarrow X_2O$.

Question 2

(a) The electron configuration of calcium was almost universally known.

(b) (i) The idea that the outer shell contains two electrons in the strontium atom was well known. This was often expressed as ‘strontium has the same number of outer electrons (as calcium)’. Other suitable responses such as ‘the same number of electrons in shell one’, were accepted.

(ii) The difference in the arrangement of electrons was successfully answered by most of the candidates. Poor wording such as ‘different numbers of outer shells’ led to loss of marks.

(c) (i) Most candidates recognised the test for hydrogen; occasionally oxygen was seen.

(ii) The identity of the OH^- (hydroxide) ion as the cause of alkalinity was known by better performing candidates. Many candidates decided to give the identity of a second ion (usually Ca^{2+}). The question clearly asked for ‘the ion responsible’ so to give a second ion resulted in the mark being lost even if they had written OH^- as one of their choices.

(iii) Sensible answers such as pH 9 or 10 were expected. The response ‘above 7’ received no credit as this encompasses pH 13 and 14.

(iv) Many candidates scored both marks. A significant minority chose to give the word equation. No credit could be given for a word equation as a chemical equation was asked for.

(d) (i) Completion of the electron arrangement of ions in the diagram was not attempted by many candidates. Presumably these candidates assumed the electron configurations were complete, having glanced at the two chloride ions, both with a full outer octet. Closer inspection would have revealed that only two shells of electrons were shown, with the configuration 2,8, and thus a third shell is needed. The magnesium ion with two electrons in the (first) shell is also incomplete.

Those who did attempt to complete the electron arrangements invariably did so correctly.

The charges on the ions were known by most candidates, whether the electron configurations had been attempted or not.

(ii) Most candidates knew three physical properties of ionic compounds and were able to state high physical constants (such as melting point), solubility in water and electrical conductivity when molten (or aqueous) – or lack of conductivity when solid.

Some candidates gave vague phrases such as ‘do not conduct electricity’ in which they did not specify ‘when solid’, or ‘conduct electricity’ in which they did not specify ‘when molten’. Others did not realise that ‘high melting point’ reflected the same property as ‘high boiling point’.

Several candidates attempted to include an extra property – often putting a ‘4’ underneath answer line 3. In many cases, this resulted in contradictory answers and candidates lost a mark.

(e) Candidates found giving the ionic equation for this precipitation reaction challenging. Most did not realise that formation of a solid precipitate comes about as a result of a reaction between two aqueous ions. Some candidates gained partial credit for realising that any two aqueous species would make one solid species; very few were able to give the correct formulae of the species.

Question 3

(a) The description of how the combustion of sulfur-containing fossil fuels leads to acid rain was generally well done. The idea of the formation of sulfur dioxide was well known as the first stage, prior to its reaction with water to produce acid rain. Many very good descriptions were seen. Some candidates did not identify the oxide of sulfur; others did not realise that sulfur needs to be oxidised initially. Other explanations such as 'reacts with water', 'dissolves in water' or 'combines with water' were accepted. 'Mixes with water' did not portray that the conversion of sulfur dioxide to acid rain was a chemical reaction.

(b) (i) Many candidates found writing a balanced symbol equation to be challenging. Nearly all candidates remembered that the symbol required to show the reversible nature of the reaction was $\rightleftharpoons$.

(ii) The essential conditions for the Contact process were known by most candidates. Errors included omitting the units on temperature (and sometimes pressure) and using an incorrect oxide of vanadium as the catalyst. In giving the conditions for the Contact process, many incorrectly opted to choose the conditions for the Haber process.

(iii) The conversion of sulfur trioxide to sulfuric acid was well known. Many opted to summarise this as the addition of water to sulfur trioxide.

(c) (i) Most candidates knew a measuring cylinder would be the ideal apparatus to use in this method. Volumetric apparatus such as burettes and pipettes were also acceptable.

(ii) Two observations indicating the reaction had finished were asked for. The expected responses were the ceasing of effervescence and appearance of a white solid (zinc carbonate) in the reaction mixture. Many candidates stated, 'when no more gas is given off', which did not receive credit as this does not explain how they would observe no more gas is given off. Other candidates suggested it was when all the zinc carbonate had dissolved, thus implying they had not understood the method being used.

(iii) Better performing candidates realised that excess carbonate needed to be added to react with (or remove) all the acid.

(iv) Many candidates struggled to explain the term *saturated solution*. Instead, descriptions of crystallisation and its associated methods were often seen. Candidates who performed less well wrote about a lack of double bonds.

(v) Many candidates left this question unanswered. Most of those who gave a state symbol assumed the zinc sulfate to be a solid. Very few realised that it was $ZnSO_4(aq)$, which should have appeared in the equation.

(vi) Only a minority of candidates knew that zinc oxide (or hydroxide) would be a suitable starting zinc compound, which could be used to make zinc sulfate by this method. The most common response was zinc nitrate, closely followed by zinc chloride. This might suggest candidates were trying to name alternative salts of zinc, which could be made by the method given.

(vii) The insolubility of barium sulfate was known by many as the reason why it could not be prepared by this method. Many went on to give excellent descriptions of how any barium sulfate formed would form an impenetrable barrier on the surface of the barium carbonate. Others who simply stated that a precipitate would form, received no credit as a precipitate is a phenomenon seen when two solutions are mixed.

(d) (i) Most candidates knew the colour of methyl orange in alkali.

(ii) Many better performing candidates were able to deduce the concentration of the acid in mol/dm^3. Very few attempted to calculate the concentration in g/dm^3.

(e) Candidates found the calculation of percentage yield to be challenging. Some were able to calculate the number of moles of $FeSO_4$ at the start and many successfully determined the number of moles of Fe_2O_3 produced. Very few were able to determine the final outcome as a percentage.

Question 4

(a) (i) The majority of candidates realised that the graph indicated a decrease in rate of reaction due to a decrease in gradient.

(ii) The reasons given for the decrease in rate of reaction seldom included the key point of the concentration of the acid decreasing.

(iii) Nearly all candidates gave 120 seconds as the finishing time. Errors came as a result of mis-reading the point at which the curve became a straight, horizontal line. Some candidates did not understand what the graph represented and opted for 240 second (the highest time value on the *x*-axis).

(b) Nearly all candidates realised smaller pieces of marble would give a quicker reaction and so gave a steeper initial start to the graph. A large proportion did not realise that as the acid was the limiting factor, then the final volume would be identical.

(c) The effect on the time taken, ‘time is decreased’, was often completely ignored by candidates. Others gave statements such as ‘the reaction would be faster’, but this is a description of the change in rate, not the change in time.

Most candidates appreciated that particles would increase in energy and thus move faster, leading to an increase in the frequency of collisions.

The mistake made by nearly all candidates who had got this far was to go on to say ‘therefore there is an increase in the frequency of successful collisions’. This gets no credit as, for example, if at any one time 10% of collisions have enough energy to allow a reaction to occur, then if the overall rate of collisions increases (e.g. doubles), it is still only 10% (i.e. the same proportion) of this higher (doubled) rate of collisions which bring about a reaction. This would explain why if the concentration of a reactant is doubled then the rate of reaction doubles. Frequency of all collisions doubles and therefore frequency of the 10% of successful collisions must also double.

The key point about increasing the energy of reacting particles is that a *greater proportion* of the collisions now have enough energy to allow a reaction to occur. So, although the rate of collisions may be doubled through greater speed of particles, far more than 10% of these collisions will now have enough energy to allow a reaction to occur.

Question 5

(a) Most candidates knew either the formula of the third member (C_4H_6) or the name of the second member of the alkynes. Care was needed in the spelling of the name to ensure there was no confusion between an alkyne suffix and an alkene suffix.

(b) The covalent bonding of ethyne was generally well done. A significant proportion of candidates decided to make the carbon-carbon connection a double bond (despite a triple bond being drawn in the table).

(c) (i) The properties of a homologous series were well known. Several candidates ignored the question requirements, which told candidates that compounds in the same homologous series have the same general formula and asked them to give two other characteristics. These candidates repeated the information in the question and wrote ‘same general formula’ as an answer.

Some candidates wrote a third characteristic. Occasionally a wrong (third) characteristic was given, this losing a mark.

(ii) Many candidates deduced the correct general formula of alkynes. $C_nH_{2n} – 2$ was not allowed where the ‘2’ was clearly large and above the line.

(d) The test for unsaturation was well known.

(e) (i) Candidates found this question challenging and many could not name the oxidising agent.

(ii) The structure of ethanoic acid showing all bonds was well drawn. Better performing candidates included the bond between the O and H in the –O–H bond.

(f) (i) The name of the ester was well known and generally, the correct structure was drawn. Methyl groups were often drawn as $–CH_3$, rather than in expanded form showing every bond.

(ii) If candidates knew the name of the ester in **(i)**, they invariably knew the name of an isomer.

(g) (i) The majority of candidate knew this was condensation polymerisation. 'Addition' was not an uncommon answer.

(ii) *Terylene* was quite well known, with 'nylon' given from some candidates. Candidates should take care with the spelling of compound names.

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Paper 0971/62
Alternative to Practical

Key messages

- Graphs - points should be clearly plotted with crosses; very small dots are not suitable. Straight line-graphs should not be drawn when a smooth line graph is requested.
- Questions requiring candidates to plan an investigation should be answered with details of apparatus to be used, substances involved and quantitative practical procedures clearly specified. The questions relating to the investigation should be clearly answered.
- Preliminary notes are advisable before writing the plan.

General comments

The majority of candidates successfully completed all questions and there was no evidence that candidates were short of time. The complete range of marks was seen with some candidates scoring very high marks.

The paper discriminated successfully between candidates of different abilities but was accessible to all.

Some candidates showed evidence of having little practical laboratory experience. This was particularly evident in **Question 1**.

The majority of candidates were able to complete the table of results from readings on diagrams and plot points successfully on a grid as in **Question 2**.

Candidates found **Question 4** to be the most demanding.

Comments on specific questions

Question 1

(a) Credit was awarded for naming the apparatus as tongs. A significant number of candidates named them as forceps, scissors or tweezers, which was not accepted.

(b) Some candidates described the appearance of the product wrongly as 'black'. Others did not read the question and discussed the reaction that occurred, with white/bright flames being common. A lack of detail was evident and 'white' was insufficient as white solid or ash was the full description required.

(c) Magnesium oxide was very well known and understood. A minority of candidates showed a lack of understanding, referring to the presence of carbon dioxide.

(d) Good answers showed an understanding that the product was heated to increase the speed of reaction or dissolving of the magnesium oxide in water. Common wrong answers were concerned with removing impurities or crystallisation.

(e) This was generally well answered.

(f) Candidates seemed not to recognise the vulnerability of eyes when carrying out this experiment and the consequent need for goggles. The use of gloves, nose masks and fume cupboards to avoid breathing in the fumes were common misconceptions.

Question 2

(a) Almost all candidates completed the table of results. A minority of candidates incorrectly recorded the time for Experiments 4 and 5 in minutes instead of seconds. Some gave times of 5 and 51 for these experiments by ignoring the minute hand.

(b) Most candidates plotted all points correctly. A common plotting error was 111 s usually at 101 s. Most curves were good attempts and dot to dot straight lines drawn with a ruler were rare. Some candidates drew a best-fit straight line when a smooth curve was the obvious choice.

(c) Many candidates clearly indicated on their graph and showed clearly where they had read their answer from the grid. Some candidates misread their scale on the *y*-axis. A minority gave no unit or the wrong unit.

(d) (i) This was generally correctly answered, with Experiment 1 given.

(ii) Better performing candidates were capable of explaining that the rate of reaction was greatest because of the higher concentration of solution **L**, or that more particles were present with the resultant increased chance or frequency of collisions. Reference to just more collisions was not sufficient for the second marking point. Some answers mentioned the increased kinetic energy or speed of the particles, which was penalised. Many responses just referred to less time of reaction and scored no credit.

(e) (i) Most candidates understood that using a graduated pipette to measure the volume of solution **L** would be more accurate.

(ii) Some candidates appreciated that using a pipette would be slower; only a minority realised that this would introduce a timing error. Vague responses such as ‘a pipette is harder/difficult to use’ were seen. Several candidates thought that a pipette could only measure a single value and would therefore have to be refilled more than once.

(f) The idea of repeating the experiments was common but many did not mention any comparison or averaging of results. The use of a burette instead of a pipette or keeping the volumes constant were suggestions that showed a lack of understanding.

Question 3

(a) The majority of candidates correctly stated that the solid was white. References to colourless and yellow were common and scored no credit. Some candidates describe solid **N** as a precipitate or as a solution.

(b) The majority of candidates reported the formation of a white precipitate. Some confused answers referred to the precipitate dissolving.

(c) This was well answered with the use of litmus paper turning blue recognised and often a good description of a pungent smell. The formation of a white precipitate was often wrongly described.

(d) Many candidates correctly identified the gas produced as ammonia, but there was some confusion between ammoni**a** and ammoni**um.**

(e) Many candidates showed a lack of understanding regarding this negative test involving aqueous sodium hydroxide. Common incorrect answers referred to solid **O** being less reactive than sodium or that no cation was present. Correct reasoning resulted in credit for identifying a non-transition metal cation, or a named metal that would not form an insoluble hydroxide precipitate e.g. ‘calcium; a Group I cation present’ was an excellent answer.

(f) Many candidates correctly identified the presence of potassium in solid **O** from the flame test. A number did not recognise the presence of chloride ions from the result of the halide test.

Question 4

The complete range of marks was seen in this planning question. Many candidates produced excellent answers and scored full credit. Other candidates scored partial credit but often did not answer the two questions:

- which reaction is exothermic and which is endothermic
- which energy change is greater?

Common errors were substituting named substances for **C** and **D**, adding water instead of acid and not detailing quantitative aspects of the investigation. Not measuring the volume of the acid or the masses of the solids showed a lack of planning. Measuring the temperature of the solids showed a lack of practical experience.

The use of heat in the investigation showed a lack of knowledge and understanding and was penalised.

There was evidence of confusion between the terms *exothermic* and *endothermic*. One misunderstanding is that endothermic reactions cause a temperature rise because of the sign of the enthalpy change, or if the temperature change were negative that would indicate an exothermic reaction.

Difficulties were encountered relating the temperature difference to the largest energy change. Some candidates thought that the magnitude or rate of temperature change was a guide to the exothermic nature of the reaction.

Candidates obtained marks for four of the following points:

- measured volume of dilute hydrochloric acid
- use of suitable container
- initial temperature of acid
- add known mass of solid **C**
- final temperature/change in temperature
- repeat with solid **D**.

Two marks were awarded for correct conclusions answering the two questions.