

PHYSICAL SCIENCE

Paper 8780/01
Multiple Choice

<i>Question Number</i>	<i>Key</i>	<i>Question Number</i>	<i>Key</i>
1	B	16	D
2	B	17	A
3	C	18	C
4	B	19	C
5	D	20	D
6	B	21	C
7	A	22	B
8	A	23	C
9	C	24	A
10	D	25	C
11	C	26	B
12	C	27	A
13	D	28	B
14	D	29	D
15	B	30	A

Key Messages

This is the third sitting of this syllabus. The performance of candidates this year was a little better than last year, but many candidates struggled with some questions. Candidates need to work relatively quickly in order to complete this paper, but not at the expense of accuracy.

General Comments

Candidates found **Questions 4, 11, 16, 27** and **29** difficult. Candidates found **Questions 6** and **24** relatively easy, showing a good understanding of diffraction, interference and the kinetic theory.

Comments on Specific Questions

Section A

Question 1

The majority of candidates showed a good understanding of both base units and dimensions.

Question 2

Many candidates incorrectly added the two absolute uncertainties.

Question 3

The most common error was to think that the formula referred to the work done by the motor and candidates who gave this option had not recognised this as a formula for power rather than for work done.

Question 4

Only a minority of candidates recognised that the work done against friction was equal to the difference between the loss in potential energy and the gain in kinetic energy. The majority, either simply calculated the loss in potential energy, or calculated the gain in kinetic energy.

Question 5

The question required candidates to first recognise that a sound wave is longitudinal in nature and so produces compressions and rarefactions. Candidates also needed to understand that compressions occur where there is high pressure (or rarefactions at low pressure) and relate this to the diagram.

Question 6

Virtually all candidates recognised that diffraction was the effect at the double slit and about two thirds went on to recognise that interference occurred at Y.

Question 7

Candidates should know that the electric field between two plates is uniform. A field is defined as the force on a stationary unit (positive) charge, thus it is logical that the force on a charge between two plates remains unchanged when the charge is moved between the plates. Many candidates showed a lack of understanding of a uniform field, thinking that the force would increase when the charge was moved nearer the negative plate.

Question 8

This was a straightforward question that caused more difficulties than anticipated. Although there were many correct answers, a significant number of candidates did not recall that that efficiency is a comparison of the useful output power (1200 MW) with the total input power (1200 MW + 2000 MW). Many candidates erroneously compared the useful output power with the 'waste' heat energy.

Question 9

Candidates coped well with this question. The most common error, surprisingly, was to consider only the 20 Ω resistor and to ignore the two resistors in parallel.

Question 10

Almost half of candidates thought that the two particles were a proton (X) and an electron (Y). All that was required was to check carefully the total nucleon number and the total proton number on each side of the equation tally.

Question 11

The question required candidates to deduce the number of isomers there are of molecular formula $C_3H_6Cl_2$. Given that three carbon atoms can only be joined in a linear fashion, we can label them C^1 , C^2 and C^3 . If the first chlorine atom is attached to C^1 , then the second chlorine atom may be attached at C^1 , C^2 or C^3 , giving the three isomers 1,1-dichloropropane, 1,2-dichloropropane and 1,3-dichloropropane. If the first chlorine atom is attached at C^2 , the second chlorine atom can also be attached at C^2 , giving 2,2-dichloropropane; if the second chlorine atom is attached to C^1 or C^3 , then the compound is 1,2-dichloropropane which has already been counted. Attaching the first chlorine atom to C^3 is a duplicate of attaching it to C^1 . So, there are four possible structural isomers of formula $C_3H_6Cl_2$.

Question 12

The question required candidates to recognise that the first ionisation process of aluminium produces the Al^+ ion. They then had to combine the equations for the second and third ionisation processes of aluminium into a single, overall, equation; i.e. converting Al^+ into Al^{3+} . The most common incorrect answer was **D** (5 structural isomers).

Question 13

This question required candidates to recall and use their understanding of the trends in the physical properties of the halogens. The answers **B** and **C** are equivalent to each other, as a substance that is the least volatile means that it has the highest boiling point; so, both answers must be incorrect. Also, it is iodine vapour that has a purple colour, not bromine; so **A** is also incorrect. Chlorine has the lowest boiling point, so is the least volatile, because it has the weakest van der Waals' forces of attraction. Over half of candidates chose the correct answer. The most common incorrect answer was **B** (Chlorine has the highest melting point).

Question 14

This question required candidates to show an understanding of the Boltzmann distribution of energies. When the temperature of a gaseous mixture is raised, the modal value (peak of the distribution) will move to higher energy (to the right) and will be reduced in abundance (will become lower). Almost two thirds of candidates chose the correct answer.

Question 15

This question required candidates to use their understanding of the chemistry of nitrates and metal oxides. The formation of brown fumes (nitrogen dioxide) and the relatively low solubility of white powder formed as a decomposition product preclude **X** from being a carbonate or a sodium salt. Almost half of candidates chose the correct answer. The most common incorrect answer was **A** ($CaCO_3$).

Question 16

This question required candidates to show an understanding of the systematic naming of organic compounds. In order to name a compound it is first necessary to identify the longest carbon chain. The fact that the most popular answers were those having propane (a three carbon chain) as their base suggests that most candidates simply looked at the horizontal part of the chain (which does contain three carbon atoms). This molecule has four carbon atoms in its longest chain, and also contains an $-OH$ group on C^2 . Its name must, therefore, be based on butan-2-ol. The presence of a methyl group on what is now defined as C^3 means that the systematic name is 3-methylbutan-2-ol. Based on the very low proportion of candidates gaining this mark, it is clear that most candidates experienced difficulty in applying the rules of nomenclature. The most common incorrect answer was **A** (1,2-dimethylpropan-1-ol).

Question 17

This question required candidates to apply their understanding of alkene and alcohol chemistry. Terpineol does have the molecular formula $C_{10}H_{18}O$, it does decolourise bromine water using its $C=C$ bond, and it does contain an alcohol group, so will form hydrogen bonds. As the alcohol is a tertiary alcohol, terpineol will not be oxidised by acidified $Cr_2O_7^{2-}$. Only about a third of candidates chose the correct answer. The most common incorrect answer was **B** (It can form hydrogen bonds between its molecules).

Question 18

This question required candidates to use their understanding of the 2,4-dinitrophenylhydrazine and Tollens' reagent tests. A positive 2,4-dinitrophenylhydrazine test indicates the presence of a carbonyl group, and a negative Tollens' reagent test indicates the absence of an aldehyde group. Compound **X** must, therefore, be a ketone. Compound **Y** is formed by reduction of **X** using $NaBH_4$. Compound **Y** must, therefore, be a secondary alcohol. Two fifths of candidates chose the correct answer. The most common incorrect answer was **A** (CH_3COCH_3).

Question 19

This question required candidates to perform a heat change calculation in order to determine a ΔH_c value. About a third of candidates chose the correct answer. The most common incorrect answer was **B** (+31.8 kJmol⁻¹).

Question 20

This question required candidates to identify an intermediate compound in a reaction sequence. The reaction sequence involves the conversion of a bromoalkane into a dibromoalkane, via an intermediate compound, **Q**. As **Q** is converted into 1,2-dibromopropane by the addition of bromine, **Q** must be propene. To convert 2-bromopropane into propene involves the elimination of HBr. This reaction requires a haloalkane to be heated with an alcoholic solution of sodium hydroxide. The vast majority of candidates correctly opted for NaOH as the reagent; slightly more than half of these candidates chose the NaOH(aq) option, which would convert **Q** into propan-2-ol, not 1,2-dibromopropane. About a third of candidates chose the correct answer.

Question 21

The question tested candidates' understanding of vectors and scalars. Surprisingly, many candidates thought that kinetic energy is a vector.

Question 22

The question tested an understanding of acceleration and forces. Although most candidates recognised that options **1** and **3** were correct, nearly a third thought that the time it took the car to stop was reduced. Applying simple logic should have led candidates to conclude that the time would increase.

Question 23

Over a half of the candidates thought that only in option **4** was there a net couple, clearly thinking that the whole rod needed to be considered.

Question 24

The vast majority of candidates showed a good understanding of the kinetic theory.

Question 25

In order to be able to complete this question candidates needed a good knowledge of definitions of different quantities, and terms and needed to work carefully through each option to ensure that the quantities match in every respect.

Question 26

This question required candidates to use their understanding of the industrial process in which aluminium is extracted from aluminium oxide. A large majority of candidates selected answers **A** or **B**, identifying responses **1** and **3** to be correct. Response **2** is incorrect, as cryolite is added to reduce the operating temperature; so, answer **B** is correct, which was given by a little under half of candidates. Those candidates who selected answer **C** presumably were confused as to the electrode on which aluminium is formed.

Question 27

This question required candidates to use their understanding of Brønsted-Lowry acids and bases. A large majority of candidates selected answers **A** or **B**, identifying responses **1** and **3** to be correct. Response **2** is, in this case, also correct, as H₂O molecules lose a proton to form OH⁻ ions. It is also a redox reaction, as the H⁺ ions are then reduced as they oxidise the Na atoms. A fifth of candidates chose the correct answer.

Question 28

This question required candidates to use their understanding of electron configurations. As the N^- ion has the electron configuration $1s^2 2s^2 2p^4$, removing an electron would leave $1s^2 2s^2 2p^3$. The O^+ ion has the electron configuration $1s^2 2s^2 2p^3$; removing an electron would leave $1s^2 2s^2 2p^2$. The Cl^+ ion has the electron configuration $1s^2 2s^2 2p^4$; removing an electron would leave $1s^2 2s^2 2p^3$. The S^{2-} ion has the electron configuration $1s^2 2s^2 2p^6$; removing an electron would leave $1s^2 2s^2 2p^5$. So, responses **1** and **3** are correct and about a third of candidates chose the correct answer.

Question 29

This question required candidates to use a range of skills. Ethanol has the M_r value of 46.0, so 0.2500 mol of ethanol has a mass of 11.50 g, not 11.25 g; response **1** is incorrect. Fehling's solution is not sufficiently powerful an oxidising agent to convert ethanol into ethanoic acid; response **2** is incorrect. Ethanal has the M_r value of 44.0, so 0.2500 mol of ethanal has a mass of 11.00 g, not 10.76 g; response **3** is incorrect. Both carbon atoms in ethanol are attached to four atoms/groups, so they show a tetrahedral arrangement around them; response **4** is correct. About a fifth of candidates chose the correct answer.

Question 30

This question required candidates to use their understanding of the part SO_2 plays in atmospheric pollution. An increase in pH would equate to a decrease in the amount of acidic gases present in the exhaust gases from the power station. Using 100% pure methane (response **1**), using calcium hydroxide to scrub the exhaust gases (response **2**) and using coal with a lower percentage sulfur content (response **3**) would all reduce the amount of SO_2 released into the atmosphere, and hence increase the pH value of the rain. So, answer **A** is correct. Using coal with higher sulfur content (response **4**) would exacerbate the problem. About two fifths of candidates chose the correct answer.

PHYSICAL SCIENCE

Paper 8780/02
Paper 2: Short Response

Key Messages

A minority of candidates were able to demonstrate a thorough knowledge and understanding of the syllabus content assessed in this paper. However, a significant number of candidates were unable to recall some of the basic facts required to form a firm understanding of key concepts in both chemistry and physics.

General Comments

There was evidence that many candidates had been given access to a wide range of relevant experiences and were thus able to attempt most questions, especially those involving the application of knowledge and of logic. However, it was clear from many responses that a significant number of candidates had not prepared well enough in order to score well across the paper as a whole.

In **Question 1** many candidates showed an understanding of the difference between random and systematic errors, but often failed to answer the question in terms of reading a burette. Candidates also had difficulties identifying the catalyst in **Question 3(a)** and had problems positioning the atomic energy levels and deducing the electron configuration in **Question 4**.

Comments on Specific Questions

Question 1

Many candidates had some understanding of random and systematic errors, but they did not answer in terms of the specific context of the question. For systematic error, many candidates referred to zero errors or errors in the mark of the scale on the burette. Although these may well lead to systematic errors these answers do not refer to the parallax error in this context.

Question 2

A majority of candidates recognised that, at the higher temperature, the modal value would be higher and the maximum number of molecules with the modal value would be lower. Candidates often failed to score both marks due to the poor drawing of their curve, notably by drawing a rise at the very end of the curve or the curve not approaching the zero line asymptotically.

Question 3

- (a) Many candidates correctly identified vanadium(V) oxide, V_2O_5 , as the catalyst in the Contact process, but a significant minority simply referred to vanadium oxide without indicating the oxidation state of vanadium, or gave iron, nickel or sodium as the answer.
- (b) Many candidates recognised that applying a lower activation energy to the Boltzmann distribution indicated an increase in the number/proportion of molecules with energy $\geq E_a$. Some went on to correctly attribute this lower activation energy to the catalysed reaction following an alternative route.

Question 4

- (a) This question tested candidates' understanding of the filling sequence for atomic orbitals, and of the capacity of each orbital type to hold electrons. As the energy of an electron in the 4s orbital is lower than that of an electron in a 3d orbital, the 4s energy level should be placed between the 3p level and the 3d level on the diagram.
Many candidates did this correctly and also gave correct maximum electron numbers at each level. As there are five different d type orbitals in a d sublevel, a maximum of 10 electrons can be accommodated there. While many candidates were aware of this, it was not unusual to see $8e^-$ written on the 4d level. Also, some candidates ignored the principle quantum numbers given on the x-axis of the diagram and placed the additional levels above incorrect principal quantum numbers.
- (b) Ionisation of a vanadium atom causes the most loosely bonded, outermost, electrons to be removed first. This means that the first electrons to be lost are those in the 4s orbital. The third electron to be removed, to leave the V^{3+} ion, is taken from a 3d orbital. A few correct answers were seen, but a large majority of candidates retained the 4s electrons in their answer and removed all of the 3d electrons.

Question 5

- (a) It was disappointing that many candidates did not study the diagram with sufficient care. It should have been clear that the spacing between the ball's positions increased to start with (showing acceleration), but became constant after about three time intervals (showing constant velocity).
- (b) This was a challenging question requiring candidates to explain, in terms of the forces acting on the ball, why it has an initial acceleration, which gradually decreases to zero. A good understanding of the relationship between the resultant force on a body and its acceleration was required to be able to give a good answer. Some candidates showed that they understood the concept, but struggled to express this clearly in their answer.

Question 6

This question required candidates to recall some Group VII chemistry. The information given in (a) unambiguously describes the behaviour of bromide ions. The addition of chlorine water to an aqueous solution of bromide ions would then cause the solution to turn an orange colour due to the oxidation of bromide ions to bromine molecules.

While, in (a), a significant minority of candidates correctly identified the cream-coloured precipitate to be silver bromide, very few showed any knowledge or understanding of the displacement reaction in (b).

Question 7

Many candidates were able to show familiarity with the free radical mechanism, so earned full marks. In many cases, the initiation stage was correctly given, but the propagation stages were usually confused and incorrect. Incorrect species used by some candidates included $Br_2\bullet$, $C_2H_4Br\bullet$, $CH_3\bullet$ and Br^- .

Question 8

- (a) (i) Most candidates knew the equation linking the speed of a wave to its frequency and wavelength, but some candidates were unable to rearrange the equation so as to find the frequency. The most common reason for losing marks was an inability to cope with powers of ten.
- (ii) Definitions must be accurate and carefully learnt. Frequency is defined as the number of wavelengths passing a point (or the number of oscillations made by a point in the wave) per unit time. The most common error is to use 'per second' rather than per unit time. Frequencies are often recorded per minute or in other time units, so 'per second' does not fully define frequency. Also, many candidates referred to the number in a given (or certain) time. This is incorrect use of terminology and should be discouraged.
- (iii) This part required candidates to recognise that frequency is constant and that a reduction in speed is accompanied by a corresponding decrease in wavelength.

Question 9

It was pleasing that many candidates were able to make suitable estimates. The most common method (and the one expected) was to estimate the mass (or volume) of the tea and the relative molecular mass, calculate the number of moles, and hence the number of molecules present. However, other methods were used; the best being to estimate the mass of the tea, and the relative molecular mass, then multiply the relative molecular mass by the mass of a proton and divide that into the mass of the tea.

The question asked for the number of molecules in the cup of tea – not the number of ‘tea molecules’ hence attempts to do a concentration calculation did not answer the question.

It should be remembered that, when giving an estimate such as this, it is not sensible to give the answer to more than a power of ten or at best one significant figure. However, no penalty was applied in this question.

Question 10

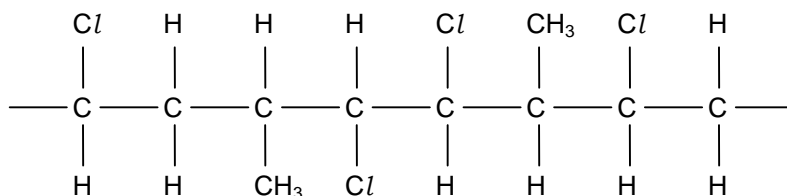
This question required an understanding of randomness and spontaneity in radioactive decay, but also required candidates to link these terms to the specific experimental results given. It was insufficient to simply state the meanings of the terms without clear reference to the results. Also many candidates failed to recognise, when looking at these results, that the isotope was clearly described in the question as having ‘a long half life’, hence one should expect there to be a roughly constant rate of decay over the short time of the experiment.

Question 11

- (a) Candidates were asked to name one monomer and to deduce the structure of another monomer used to prepare a fragment of a polymeric chain.

The correct name for compound **A**, 1-chloropropene, was given by some candidates. The most frequently seen incorrect names were chloropropene or monochloropropene; as the three carbon atoms have different bonding arrangements, the position of the chlorine atom must be given. Other incorrect names included 1-methyl-2-chloroethene and 1-chloro-2-methylpropane.

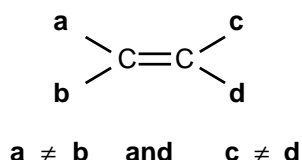
As the monomers were defined as being monochloroalkenes in the question, the identity of the other monomer can be deduced by considering the structure of the polymer fragment.



In this fragment, the fourth and fifth carbon atoms in the main chain each carry chlorine atoms and so must have come from separate monochloroalkene monomers. Thus, the first and second carbon atoms in the chain must have been provided by chloroethene; this is therefore compound **B**.

Many candidates exercised similar logic and were able to correctly identify compound **B**. However, a range of incorrect suggestions, such as 1,2-dichloroethene, 1-chloropropene and various chlorobutenes, were seen.

- (b) Many candidates recognised that compound **A** contained a non-rotatable double bond between carbon atoms. Very few, however, then went on to describe how **A** fulfilled the requirements shown below; i.e. that $\text{CH}_3 \neq \text{H}$ and $\text{H} \neq \text{Cl}$.



PHYSICAL SCIENCE

Paper 8780/03

Paper 3: Structured Questions

Key Messages

A minority of candidates showed a good knowledge of facts and key concepts expected. However, a significant number showed little awareness of even the basic of facts, which prevented many from being able to use simple techniques to solve problems.

When choosing to identify compounds, candidates have the choice of giving the name or the formula of the compound. If the latter option is chosen, candidates must be sure that the formula they write contains no flaws.

It should be emphasised to candidates how vital it is that they communicate clearly. A jumble of numbers with no explanation will not usually gain full marks in questions requiring mathematical solutions, for example in **Question 9(c)(i)** where candidates were asked to show the specific value of a current, and **Question 10(a)(i)** where the calculation of a molar enthalpy change was required.

General Comments

Poor preparation by some candidates continues to be evident. There remains a wide range of the level of preparedness of the candidates for the examination. Some candidates were well placed to tackle an examination at this level having received comprehensive and relevant experience. However, there are many candidates who have evidently not had the advantages of such preparation. This was particularly noticeable in **Question 6(a)** where many candidates were unable to recall straightforward details concerning the electrolytic purification of copper.

Overall, **Questions 4(b)** (vector diagram), **8(c)** (mechanism), **9** (networks and Kirchhoff's Laws), **10(a)(ii)** (redox) and **10(b)(i)** (equations) proved the most problematic with very few candidates scoring well. Whilst a small minority of candidates were able to complete the vector diagram in **Question 4(b)**, virtually no candidates showed any real understanding of how to tackle the challenges in **Questions 8(c)**, and **10(b)(i)**.

Comments on Specific Questions

Question 1

This question is designed to test an understanding of Group II chemistry and trends. Performance varied considerably across the candidates who took this paper. Some excellent answers were seen, but also some very poor ones, suggesting that some candidates were not particularly well-prepared to answer questions on this topic. In a significant number of cases, no attempt was made to answer all or part of the question.

- (a) In many cases, the identities of **A**, **B** and **C** were correctly deduced to be strontium hydroxide, strontium sulfate and strontium nitrate, respectively. Most candidates chose to identify these compounds by formula, rather than by name. When offered, the names tended to be correct, however, there were many errors in the formulae. Examples of incorrect formulae include SrOH, SrSO, SrO₃, Sr(SO₄)₂ and SrNO₃. Other errors included strontium dioxide, SrO₃ and H₂SrO₂.

Where a candidate gives a correct name in addition to an incorrect formula, or vice versa, the incorrect answer negates the mark for the correct answer.

- (b) This question is based on the trends in thermal stability of the Group II carbonates and nitrates, which increases down the group. To answer the question it was necessary for candidates to deduce the identity of compound **D** to be strontium carbonate. In part (b)(i), many candidates recognised that this reaction involved the thermal decomposition of strontium carbonate and so quoted high temperature or heat as the main condition. Incorrect answers included light, high pressure, reaction with an acid or the use of a catalyst.

In part (b)(ii), those candidates who had identified compound **D** as SrCO₃ in part (b)(i) tended to write the correct equation. Incorrect equations, containing compounds other than SrCO₃ were quite often seen.

- (c) The definition of *empirical formula* required in part (c)(i) was not well known. A definition along the lines of the one below would have been acceptable.

(The empirical formula is) *the simplest whole-number ratio of atoms of each element in a compound.*

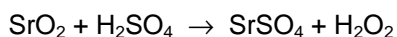
In most cases, candidates offered definitions similar to that above, but often lacked a reference either to *atoms* or to *element*. Some candidates gave an acceptable definition based on the mole ratio of elements in a compound.

Part (c)(ii) was, generally well answered, with many candidates correctly determining the empirical formula to be SrO₂.

Candidates are instructed in the question to calculate the empirical formula of compound **E**. In some cases, the correct formula was given, but was not supported by calculation. In the absence of supporting evidence, full marks were not awarded.

Part (c)(iii) was poorly done. In order to answer this question, it was necessary to deduce that compound **B** was SrSO₄; most candidates did this in part (a). The question states that in the reaction between **E** and sulfuric acid, **B** is formed plus **one** other compound.

Writing a balanced equation for the reaction should unambiguously identify compound **X** as hydrogen peroxide, H₂O₂, as taking away SrSO₄ from SrO₂ + H₂SO₄ leaves two hydrogen atoms and two oxygen atoms unaccounted for on the right hand side of the equation.



A few candidates made this deduction, but most identified compound **X** as either water or oxygen.

Question 2

This question covered the dynamics of collisions and explored the candidates' understanding of the concept of elastic and inelastic collisions.

- (a) Virtually every candidate recognised that the negative sign in the glider's velocity meant that it had rebounded from the second glider and was moving in the opposite direction compared to its initial direction.
- (b) Whilst the majority of candidates recognised that this was a problem requiring the use of the conservation of momentum, many confused the momenta of the two gliders after the collision and thought that the rebounding glider's momentum should go on the same side of the equation as the initial momentum.
- (c) There were some good answers to this, however, there were many which showed little understanding. A significant number thought that, if momentum is conserved, then the collision is elastic, others recognised that for an elastic collision the kinetic energy must be conserved, but were then unable to calculate kinetic energy. The failure to state that the total kinetic energy of the gliders after the collision was less than their kinetic energy before the collision caused some candidates, who otherwise answered the question well, to lose credit.

Question 3

This was a quite demanding question, which was designed to test how well candidates were able to apply their knowledge and understanding of periodic trends in acidity and basicity to a novel situation.

The label, actually found on a bottle of liquid tomato feed, claims that the feed contains aqueous solutions of K_2O and P_4O_{10} . In order to answer this question, an understanding of the trend in the reactions of Period 3 oxides with water, and of acid-base behaviour, is required. Candidates were expected to deduce that both K_2O and P_4O_{10} would react with water to form KOH and H_3PO_4 , respectively. Simultaneously, these would then undergo a neutralisation reaction to form the salt, K_3PO_4 .

Some very good attempts were seen. Overall, most candidates deduced at least part of this explanation. It was encouraging to see good chemical explanations being offered, albeit, in most cases, on an incomplete basis. A few candidates, however, focused on the phrase *trends across Period 3* and simply described Period 3 trends such as those in ionisation energy, size and conductivity, etc.

Question 4

- (a) The conditions for equilibrium (the resultant moment about any point is zero and the resultant force is zero) are basic knowledge, which all candidates should know and learn. It was disappointing to note how few candidates gained full marks and how many had little or no knowledge of these conditions.
- (b) The drawing of the vector triangle proved very difficult; perhaps made more challenging because the three forces did not appear to go through a single point. Practise is required for candidates to gain the experience of drawing vector diagrams for arrange of contexts.

Question 5

- (a) This definition of the principle of superposition was not well known. A common error here was to give the definition in terms of the resultant amplitude being equal to the sum of the two (or more) amplitudes. This is true only when the waves have a phase difference of exactly $360n^\circ$ (where n is a whole number). The definition requires the general case: the sum of the individual displacements at a point being equal to the resultant displacement, which is true at all points, whatever the phase difference and at all moments of time.
- (b)(i) A good number of candidates understood that interference occurs and that the amplitude of the wave on the cathode-ray oscilloscope (c.r.o.) would vary, going from maximum to minimum several times. It should be noted that the question asks the candidates to record what would be observed on the c.r.o. screen; consequently answers in terms of sound level could not score the mark.
- (ii) A good number of candidates recognised that the wavelength of the waves on the screen would decrease; fewer recognised that the maxima and minima would be closer together. The majority recognised that the amplitude increased, although a few thought that the maxima/minima positions would change.
- (iii) This part was designed to test candidates' ability to use their knowledge in a novel situation. It was done quite well, with many candidates scoring the first mark, but fewer going on to give a good explanation as to why interference would be avoided.

Question 6

This question required candidates to recall industrial processes in part (a) and to apply their understanding of the fundamental principles of equilibria in part (b). Part (a) was, in the main, quite poorly done, suggesting that many candidates had not prepared themselves adequately for this type of question. However, the responses to part (b) were quite encouraging, suggesting that many candidates had a reasonable working understanding of equilibria.

- (a) This question required candidates to recall the basic details of the electrolytic purification of copper. While some candidates had revised this topic thoroughly, and so were able to show understanding of this process, many attempts were confused or incomplete. In some instances, candidates drew diagrams of the electrolytic cell used in the extraction of aluminium.

- (b) This question required candidates to apply their understanding of Le Chatelier's Principle to a reversible reaction involving coloured copper(II) ions. The addition of sodium chloride raises the (Cl^-) and so drives the equilibrium to the right in order to reduce this concentration. This increases the $(CuCl_4)^{2-}$ and so the colour of the solution changes from blue to green. This was well understood by most candidates, although many referred simply to there being more chloride ions present, rather than to their concentration increasing.

The explanation for the effect on the equilibrium of adding water to the green mixture was not well understood. Many candidates simply referred to there now being more water, or an increase in the concentration of water, in the mixture, and constructed a Le Chatelier argument based on this. In fact, the (H_2O) is massive and the addition of extra water makes very little difference to this concentration.

Adding water reduces $[Cu(H_2O)_6]^{2+}$, (Cl^-) and $(CuCl_4)^{2-}$, so that the rates of the forward reaction, R_f , and the backwards reaction, R_b , are both reduced. However, the effect of reducing both $[Cu(H_2O)_6]^{2+}$ and (Cl^-) has a greater effect on R_f than reducing $(CuCl_4)^{2-}$ has on R_b . So, R_f is reduced more than R_b and the backwards reaction is favoured.

Overall, some candidates coped well with the question and most were able to demonstrate some understanding of the principles involved.

Question 7

- (a) (i) There were some good answers to this question with many candidates accurately calculating the gradient of the graph, although powers of ten did cause some difficulty. A common error, amongst those who did not gain marks, was simply to take velocity at an instant divided by the time indicated on the graph at that instant.
- (ii) There were some good answers to this part, with the majority of candidates recognising that they needed to look up the mass of an electron in the Data Booklet.
- (b) Few candidates scored both marks on this part. Whilst most candidates recognised that the gradient of the graph (the acceleration) would be greater, few recognised that that the final velocity would also be greater and that the electron would spend less time between the plates. Common errors were to think that the initial speed would be greater, or that the electrons would enter the field sooner.
- (c) Although there were some good answers to this part, a significant number of candidates were confused and did not use the electronic charge ($1.6 \times 10^{-19} C$) in the formula $E = F/q$.

Question 8

This question assessed candidates' understanding of oxidation, elimination, addition and nucleophilic substitution processes. While some good attempts were seen, many candidates struggled with some parts of this question.

- (a) The stem of this part indicates that **P** is a reducing agent by its reaction with acidified potassium dichromate(VI). In addition, the reaction scheme shows **P** being dehydrated by concentrated sulfuric acid to form an alkene. Many candidates correctly deduced **P** to be an alcohol; of these, a fair number also correctly identified it as 2-methylpropan-1-ol. Some candidates suggested incorrect alcohols such as propanol or butanol and a wide range of other incorrect answers were also seen here.

In (a)(ii), many candidates correctly identified the conversion of **P** into **Q** as involving dehydration or elimination. Incorrect answers included addition, substitution, reduction and hydrolysis.

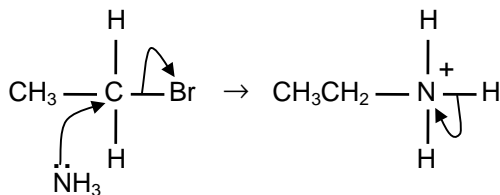
In (a)(iii), many candidates correctly identified **X** as being hydrogen bromide. The most common incorrect answer was bromine. Some candidates tried to hedge their bets by writing both hydrogen bromide and bromine; in such cases, bromine negated the mark for hydrogen bromide.

- (b) Many candidates correctly named **R** as 1-bromo-2-methylpropane; 2-methyl-1-bromopropane was also accepted. Some candidates spoiled their answers by giving an incorrect position for the bromine atom; i.e. 2-bromo-2-methylpropane or 3-bromo-2-methylpropane. Other incorrect names, including 1-bromo-2-methylbutane, 1-bromo-2,2-dimethylethane and 1-dimethyl-2-ethane were also seen.
- (c) In (c)(i), many candidates correctly identified **S** as being an amine, however, suggestions such as amide, nitrile and even aldehyde were quite often seen.

The mechanism in (c)(ii) was poorly done. While some candidates earned one or two of the four marks available, four marks was only very rarely awarded. The required mechanism was identified in the question as an S_N2 mechanism (this is the only nucleophilic substitution mechanism quoted in the syllabus).

In this mechanism, the lone pair on the nucleophile attacks the electron deficient (δ⁺) carbon to which the bromine atom is attached. This attack is shown by a curly arrow from the lone pair on the nucleophile to carbon atom. Simultaneously, the C–Br bond breaks and this electron pair moves onto the bromine atom, forming a bromide ion, as shown by a curly arrow from the C–Br bond onto the bromine atom. When the nucleophile is OH[−] or CN[−], the mechanism is then complete.

When, as in this case, ammonia is the nucleophile, an ethylammonium ion is formed as an intermediate; this is deprotonated to leave ethylamine. The deprotonation step is shown by a curly arrow from the N–H bond onto the N atom. See the mechanism drawn below.



Question 9

- (a) The definition of potential difference had not been learnt by the majority of candidates.
- (b) Candidates struggled with this network and would benefit from practice in analysing a range of networks and perhaps drawing them in a more familiar format. It should have been clear to candidates that the network consists of three 200 Ω resistors in series, connected in parallel with another 200 Ω resistor, giving a total resistance of 150 Ω between **X** and **Y**.
- (c) (i) Most candidates scored this mark, however, few really explained how they obtained their figures. A good answer would explain that there are two 200 Ω resistors in series, giving a total resistance of 400 Ω and the potential difference across these is 6.0 V, hence the current is 6 / 400 = 0.015 A.
- (ii) A lack of understanding for many candidates was evident here. Although quite a lot of candidates were able to calculate that there was a potential drop of 3.0 V across **DA**, few realised that there was an equal potential drop across **DC**, and as a consequence, that the potential difference across **AC** was zero.
- (iii) Although most candidates were able to determine the resistance of the thermistor as 600 Ω, very few could go further to show corresponding current in **DC**. Virtually no candidates considered the total resistance across the two arms, **DAB** and **DCB**.
- (iv) Candidates who struggled with part (c)(iii) often had difficulties with this part too, despite all the information required having been already given in the question. Virtually no candidates showed the understanding required to use Kirchhoff's second law.

Question 10

This question covered a wide range of topics, all of which required candidates to apply their understanding of chemical principles. Most candidates were able to cope with at least some parts of the question.

- (a) In part (a)(i), candidates were required to obtain appropriate bond energy data from the Data Booklet and use it to calculate a molar enthalpy change for a reaction. Many candidates coped well here, but a substantial minority struggled with this question. Most candidates used an approach similar to the one shown below. Quite frequently, however, the expression was reversed and/or incorrect numbers of individual bond types were used.

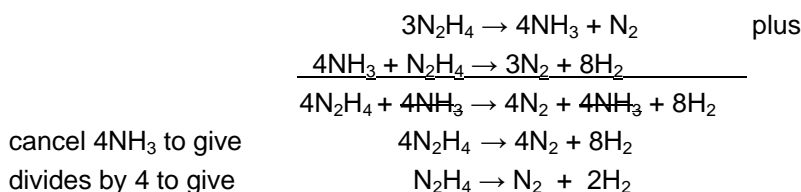
$$\Delta H = \Sigma(\text{bonds broken}) - \Sigma(\text{bonds formed})$$
$$= [(4 \times \text{N-H}) + \text{N-N} + (2 \times \text{O-O}) + (4 \times \text{O-H})] - [\text{N}\equiv\text{N} + (8 \times \text{O-H})]$$

In part (a)(ii), candidates were asked to identify the element that was reduced and the element that was oxidised, in the redox reaction. Their choices should then have been supported by explanations based on changes to the oxidation numbers of these elements. So, oxygen is reduced, as its oxidation number decreases from -1 , in H_2O_2 , to -2 , in H_2O and nitrogen is oxidised, as its oxidation number rises from -2 , in N_2H_4 , to zero in N_2 .

While some candidates coped well with this part, many candidates misinterpreted this question completely and described how hydrazine and hydrogen peroxide were reduced/oxidised. Others either correctly identified the elements, but described incorrect oxidation state changes, or gave correct oxidation state changes, but wrote that oxygen was oxidised and nitrogen reduced.

- (b) Many candidates struggled with part (b)(i). In order to write an overall equation for a reaction using the equations for two separate stages in the reaction, it is first necessary to identify the products from one equation that serve as reactants in the other equation. In some cases, it is then necessary to scale one or both of the original equations to allow the products/reactants to cancel out when the equations are added.

In this case, ammonia is produced in **stage 1** and consumed in **stage 2**, however, the amount of ammonia produced and consumed is the same, i.e. 4NH_3 ; so, scaling is not needed here. When added, the equations for **stages 1** and **2** are processed as shown below.



While some candidates were able to do this, many struggled or did not attempt the question.

In part (b)(ii), candidates were required to use the ideal gas equation to calculate the final pressure in a tank containing hydrazine that had been decomposed completely into its elements. In order to do this, it was necessary to use the equation given in part (b)(i) to determine the mole ratio between hydrazine and the nitrogen/hydrogen mixture produced on decomposition.

From the equation, $\text{N}_2\text{H}_4 \rightarrow \text{N}_2 + 2\text{H}_2$, it can be seen that one mole of hydrazine produces three moles of gaseous product.

The vast majority of candidates were able to use the ideal gas equation correctly, but very few considered the mole ratio described above. As a consequence, the correct value for the pressure (11 842 kPa) was very rarely seen. By far the most common answer was 3947 kPa, which resulted from using the number of moles of hydrazine (12.5 mol), rather than the number of moles of gaseous products ($3 \times 12.5 = 37.5$ mol), in the calculation. Other incorrect answers were seen, most of which resulted from unnecessary changes being made to the temperature or volume values, or from arithmetical errors.

Question 11

- (a) The majority of candidates demonstrated a reasonable knowledge and understanding of the α -particle scattering experiment.
- (b)(i) Although there were some good answers, a lot of candidates failed to answer the question that was asked and failed to establish evidence for the positive nature of the nucleus.
- (ii) Many good answers were seen to this part.

PHYSICAL SCIENCE

Paper 8780/04
Advanced Practical Skills

General comments

The paper set for this, the third year of this AS level examination, was appropriate for the candidates who were entered for it. However, the marks gained overall were not quite as high as those in previous years.

This practical work involved proved to be the right level of difficulty in that it enabled almost all candidates to carry out the manipulative work required. Some candidates had difficulties processing their results, which is where some did not gain all of the available marks.

Taken together, both questions produced a satisfactory distribution of marks with nearly the full range available being used.

Candidates had enough time to complete the paper; there is almost no evidence that they ran out of time.

The practical skills required proved to be within the capabilities of most candidates. Candidates lost marks by not taking enough care with the titration and in the drawing of graphs and in the processing of results.

Where candidates experienced difficulties it was possibly because they had not had enough previous opportunity to do practical work, especially titrations.

Some candidates, fewer than previously, did not make enough consideration of the use of consistent significant figures and/or decimal points when making measurements in the Physics question.

It is important that candidates continue to take care when recording their observations and to use acceptable terminology with units.

Comments on specific questions

Question 1

This experiment seems to have worked very well for most candidates.

It proved to be well within the capabilities of most candidates to carry out the experiment and to obtain valid results.

Most candidates followed the instructions well and were able to make a reasonable attempt at the experiment. Candidates lost marks in making mistakes in the graph drawing and subsequent parts of the question.

- (a) A significant number of candidates (and some Supervisors) measured the wrong angle. They measured $(90 - \theta)$ instead of θ .
- (b) Almost 100% of candidates were able to construct a suitable table for the measurements.

The most common errors were to omit the units from the headings and write them after each recorded measurement. This practice is not an acceptable way of including units.

The use of significant figures was better than previous years, but a few candidates are still inconsistent. It was pleasing to see that most candidates were able to calculate $\cos \theta$ correctly, although a few tried to give it units.

- (d)(i) The standard of graph drawing was generally good. It was pleasing to see that, compared to previous years fewer candidates used an awkward scale or tried to joint points instead of a straight line. Units were sometimes omitted from the axes labels. Some candidates continue to make minor, careless plotting errors. It was obvious that most candidates ignored the instruction in the question and drew the line before going on to part (ii).
- (ii) This was done reasonably well except that many candidates only included the new point on the graph: they did not record their results as requested. On this occasion they were not penalised.
- (iv) Compared to previous years candidates were better able to calculate the gradient of the line of best fit drawn. Candidates should make their triangles as large as possible and this year there were only a few candidates who used triangles that were too small. It was pleasing to see that only a handful of candidates tried to calculate a gradient from a single set of readings or from figures from their results table.
- (e) Many candidates did not understand what was required of them here. They were not able to cope with the algebra needed to rearrange the formula given in order to determine a value for Z.
- (f) Suggested sources of error must be clear. Answers such as “parallax” or “wobbled” are insufficient. More detail is expected.

Question 2

The vast majority of candidates were able to carry out the tests and obtain results. Candidates lost marks because of careless experimentation or sloppy recording.

During wet tests candidates need to state “white precipitate” where appropriate. Answers such as “milky”, “chalky”, or “white cloudiness” are **only** acceptable in the limewater test for carbon dioxide.

- (a) (i) Most candidates were able to construct a suitable results table. However, burette readings must be labelled as “readings” not “volumes”: only the titres are volumes.

Some candidates used ml instead of cm^3 . Whilst this is not incorrect, it is better for the up-to-date units to be used. Units need to be included in the headings for all columns, including readings.

Candidates need to record all their readings for accurate titrations to 0.05 cm^3 . This means that their readings should end in .00 or .05.

It is expected that candidates should obtain two concordant titres within 0.1 cm^3 of each other.

- (ii) Candidates tended, incorrectly, to calculate the average of all their titres rather than just using the concordant ones.
- (iii) Whilst many candidates gave the correct answer, a significant number thought that sulfuric acid was an indicator.
- (iv) Many candidates realised that a factor of 5 was involved, but more than half could not do the correct calculation involving the ratio of the titration volumes. Some candidates had the volumes the wrong way round and some candidates did not know how to calculate the required concentration.
- (v) Only a small number of candidates realised that they needed to multiply their answer for (iv) by the relative atomic mass of iron.
- (b)(i) The observations were generally good. However, some candidates either failed to add an excess of sodium hydroxide or failed to mix thoroughly by shaking.
- (ii) Many candidates gave chromium instead of iron(II). Others put ammonia instead of ammonium.
- (iii) Few candidates realised that this was an oxidation process either by using the word “oxidation” or by stating that “iron(II) was converted to iron(III)”.