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Examiners' Report
June 2016

GCE Chemistry 8CH0 01

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Introduction

The general performance of candidates across the whole paper was pleasing and many questions proved to be very effective discriminators providing opportunities for candidates of all abilities to demonstrate their knowledge and understanding.

The following clips of candidate responses and the associated comments/tips serve as useful aids in highlighting key areas for improvement and vital pointers in avoiding common errors in answering such questions.

Question 1 (a)

This proved to be an effective opening question because it proved accessible to all candidates, but provided some differentiation as less able candidates tended to score one mark while more able candidates often scored two marks.

1 This question is about Group 7 elements and their compounds.

(a) (i) Give the physical states of chlorine and iodine at room temperature and pressure.

(1)

Chlorine is gaseous and iodine is solid

(ii) Predict the physical state of astatine under these conditions. Justify your answer.

(1)

Astatine is solid, because it will have a higher boiling point than iodine.

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Examiner Comments

The question in part (i) simply requires the physical states of the two halogens to be given and this is correctly done here. However in part (ii) the question requires a justification which should be at an appropriate standard. In this example the justification may be sufficient for GCSE but not at this level. Hence no mark was awarded for part (ii).

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Examiner Tip

Always pay close attention to the precise wording of the question and then construct an answer accordingly.

1 This question is about Group 7 elements and their compounds.

(a) (i) Give the physical states of chlorine and iodine at room temperature and pressure.

(1)

Chlorine is a gas and iodine is a solid

(ii) Predict the physical state of astatine under these conditions. Justify your answer.

(1)

I predict it would also be a solid as it is very reactive which would form a lattice structure like iodine does as London forces get stronger down the group.

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Examiner Comments

The answer given in this response for part (ii) is clearly of a much higher standard than the previous one and correctly refers to the strength of the London forces as the justification for the solid state of astatine.

Question 1 (b)

This proved to be a clear 'step up' in difficulty from part (a) since only the more able candidates could consistently score on this question. The mark for the type of reaction was the most common mark awarded. It was noticeable that the equations written were balanced which has been an issue raised in previous specifications, however the chemistry of the substances involved is also an important point to consider and this appeared to be lacking in many responses.

(b) Write the equation for the reaction of chlorine with cold, dilute sodium hydroxide solution to form bleach. Name this type of reaction.

(2)

Disproportionation reaction.

Type of reaction $Cl_{2(aq)} + NaOH_{(aq)} \rightarrow NaClO_{(aq)} + HCl_{(g)}$

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Examiner Comments

It may be that this candidate was rushing their answer and so didn't pay attention to the rubric of the question. The initial space was left blank for the candidates to write their equation and then the dotted line at the bottom was for the type of reaction. However the correct chemistry will always be credited and in this example the mark for the type of reaction was awarded.

The equation is balanced and this is important but the chemical nature of the products appears to have been missed. An acid would not be made in the presence of an alkali.

Thus this response scores one mark.

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Examiner Tip

Candidates are best-advised to formulate their answer according to any 'scaffolding' given in the question.

It is vital to remember the chemical nature of the substances in a chemical equation since this will help to write the correct products.

(b) Write the equation for the reaction of chlorine with cold, dilute sodium hydroxide solution to form bleach. Name this type of reaction.

(2)

$2Cl + 2NaOH \rightarrow NaCl + NaOCl + H_2O$

Type of reaction disproportionation

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Examiner Comments

Another example here of a balanced equation but with the correct products. However the reactant chlorine is a diatomic molecule and not single atoms. Hence only the mark for the type of reaction was awarded.

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Examiner Tip

The knowledge and understanding from GCSE must be retained. The most challenging part of this question is the formulation of the products. To get these right, but then make the simple error in the formula of the chlorine is disappointing. The formula of chlorine would have been learnt in GCSE and this is needed as a foundation to build on with more complex chemistry.

Question 1 (d)

The most surprising, and disappointing, aspect of this question was that a significant minority of candidates clearly did not read the question but just focused on the chemical formula of the substance. This was evidently the case because some candidates wrote about carbon and iodine with fluorine but the name of the substance, chlorine trifluoride, was clearly and purposely given in the question instruction.

In addition the word 'bonds' was emboldened because there was no credit for comments on the overall polarity of the chlorine trifluoride molecule. This point was also missed by a large number of candidates.

Less able candidates were often able to gain the mark for the definition of electronegativity but no more. The second mark for the greater electronegativity of the fluorine in comparison to the chlorine proved accessible to many, and the third mark for the correct dipoles seemed to be only awarded to the very able candidates. In this way the question served as an excellent discriminator.

It would be useful for candidates to practice the use of provided data to support their explanations.

(d) State what is meant by the term electronegativity and hence explain the polarity, if any, of the **bonds** in chlorine trifluoride, ClF_3.

(3)

Electronegativity is the ability of an atom in a molecule to attract a pair of e^- in a covalent bond, however there ~~ere~~ ~~ere~~ is no polarity for chlorine trifluoride as the dipoles cancel out.

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Examiner Comments

The definition of electronegativity is nicely expressed and worthy of one mark.

The identity of the dipoles in chlorine trifluoride is not stated, nor any reason for them. Thus no further credit was given for this response.

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Examiner Tip

Candidates must make time to re-read their answers and to re-read the question to make sure that the two match.

(d) State what is meant by the term electronegativity and hence explain the polarity, if any, of the **bonds** in chlorine trifluoride, ClF_3.

(3)

Electronegativity is an atom's ability to attract electrons to itself in a covalent bond. The Cl-F bonds will be slightly polar, because fluorine is more electronegative than chlorine, so will have a δ^- charge.

~~F~~ Florine has an electronegativity index of 4.0 whereas Chlorine is 3.0.

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Examiner Comments

This response scored two of the three marks available. The third mark is almost given but only the dipole on the fluorine has been stated. There were responses seen where both fluorine and chlorine were given delta negative dipoles and so the absence of the dipole on the chlorine, as in this case, cannot be taken to be that the chlorine is delta positive. This has to be clearly stated.

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Examiner Tip

Candidates must make sure that all aspects of their answer clearly and explicitly state the necessary points. The examiner is not in a position to infer what the candidate means.

Question 2 (a)

This proved to be a high-scoring question, with a mean of over 1.7. It was pleasing that candidates were able to identify and to correct a number of errors in the excerpt which demonstrates a good level of understanding of this topic area. The most common correct response, not unsurprisingly, was the statement that electrons are found in the nucleus. Occasionally an incorrect comment to the effect that the isotopes had 18 or 20 electrons in the shells was seen.

error   error

"Some of the electrons are also contained in the nucleus, whilst the remainder are ..... arranged in rings revolving round the nucleus ..... The two isotopes [of chlorine] have therefore 18 and 20 electrons respectively in the nucleus and 17 [electrons] external to it."

(a) Identify and correct **two** errors in the excerpt.

(2)

No electrons are found in the nucleus they are all found in Quantum Shells around the nucleus. The electrons do not revolve around the nucleus they live in areas called Orbitals.

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Examiner Comments

An example of a good response which scores both marks.

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Examiner Tip

It can often be a helpful practice when constructing an answer for key parts in the question to be highlighted or 'ringed' as in this instance.

Question 2 (c)(i)

Another high-scoring question on a topic that candidates had clearly learnt very well.

(c) (i) State what is meant by the term **relative atomic mass**.

(2)

Relative atomic mass is the mass of an atom divided by 1/12 the mass of 1 Carbon-12 atom

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Examiner Comments

This is an example of a response where the point about the relative atomic mass being a mean or an average (of the isotopes) is missing and so only scores one mark for the comment about the reference standard, one twelfth of carbon-12.

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Examiner Tip

Definitions are well-worth learning thoroughly as they tend to be easier marks to obtain.

(c) (i) State what is meant by the term **relative atomic mass**.

(2)

Mean weighed mass of an atom compared to the mass of carbon 1/12.

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Examiner Comments

The second half of this response appears to have been rushed and so the point about the reference being a twelfth of carbon-12 has been merged into one incorrect comment. However the opening comment did gain one mark.

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Examiner Tip

Careful checking of written answers often identifies errors that can be corrected relatively easily.

Question 2 (c)(ii)

This relative atomic mass calculation was accessible to the vast majority of candidates with a good spread of marks across the whole ability range. The advice given on the front of the exam paper is that all working in calculations should be shown and this was true in this instance.

This was the first question on the paper where the new style of wording such that the answer be quoted to "an appropriate number of significant figures" was used. The vast majority of candidates responded correctly and did not give an answer to an excessive number of significant figures.

However a small minority of candidates ignored the more precise values for the two isotopes and simply used 6 and 7. This error was penalised by one mark.

It was also disappointing at times to see candidates give a final answer which was not between 6 and 7. Evidently these candidates had 'lost sight' of the subject of the question and surely would have benefitted from a careful review of their answer.

(ii) A 5.000 g sample of lithium, containing the two isotopes lithium-6 and lithium-7, was found to contain 0.460 g of the isotope lithium-6.

Calculate the relative atomic mass of lithium for this sample. Give your answer to an appropriate number of significant figures.

Isotope	Relative isotopic mass
Lithium-6	6.015
Lithium-7	7.016

(3)

$$A_r = \frac{(6.015 \times 9.2) + (7.016 \times 90.8)}{100} \qquad \frac{0.460}{5.000} \times 100 = 9.2\%$$

$$= 6.923$$

$$= 6.92$$

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Examiner Comments

Incorrect rounding within a calculation will be penalised as this is in harmony with the increased mathematical demand of the new specification. In this response the initial answer given is 6.923 but this is incorrect and so was penalised, even though the final answer of 6.92 is the correct mark scheme answer. This may lead some to feel that working should not be shown but this example is an unusual one and for the vast majority of responses the working shown helped to award maximum credit for the answer given.

ResultsPlus
Examiner Tip

Significant figures is an integral part of the new specification and the number quoted should not be given to more significant figures than the data provided.

(ii) A 5.000 g sample of lithium, containing the two isotopes lithium-6 and lithium-7, was found to contain 0.460 g of the isotope lithium-6.

Calculate the relative atomic mass of lithium for this sample. Give your answer to an appropriate number of significant figures.

Isotope	Relative isotopic mass
0.460 g → Lithium-6	6.015
4.54 g → Lithium-7	7.016

(3)

5 − 0.460 = 4.54

1) [(0.460 × 6.015) + (4.54 × 7.016)] ÷ 5

2) (2.7669 + 31.85264) / 5

3) 34.61954 / 5 = 6.923908

or 6.934 g (3 sf)

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Examiner Comments

This candidate has laid out their answer relatively clearly and put a box around their final answer which is fine. However relative atomic mass should not have any units. At times the units of 'molar mass', g mol^{-1}, maybe ignored but not 'g' as given here. Hence this response scores two marks and not three.

ResultsPlus
Examiner Tip

In chemistry calculations it is certainly true that units are important and must be given where needed. However on certain occasions, such as relative atomic mass, there are no units.

Question 2 (d)

This was a highly-discriminating question, with only the very able candidates scoring any marks. The question was an application of the specification Topic 1.9 and candidates at the 'top end' will have their knowledge and understanding stretched. It was pleasing to see that these candidates were often able to explain the origin of a small mass spectrum peak at *m/z* = 80.

One fairly frequently-seen error was one that referred to the presence of carbon-13, but this was a pure sample of bromine so an unfortunate complete loss of grasp of the question.

(d) A mass spectrometer was used to analyse a sample of bromine, Br_2, with only the ^{79}Br and ^{81}Br isotopes present.

Explain why a very small peak occurs at $m/z = 80$.

(2)

during ionisation Br_2 gets hit with so much force that ^{80}Br isotopes can form in a small quantity

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Examiner Comments

This is an example of an incorrect response that was commonly seen. The mass spectrometer was often perceived to be similar to the Hadron Collider and capable of creating new isotopes but this is not the case.

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Examiner Tip

It is always best to attempt every question because even if incorrect there can be no marks deducted for this.

(d) A mass spectrometer was used to analyse a sample of bromine, Br_2, with only the ^{79}Br and ^{81}Br isotopes present.

Explain why a very small peak occurs at $m/z = 80$.

(2)

As Br_2 is diatomic a ^{79}Br and ^{81}Br could have bonded together to form Br_2 with molar mass of 160. However in the mass spectrometer, ~~that~~ it formed a +2 ion giving it a mass to charge density of $\frac{160}{2} = 80$

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Examiner Comments

An example of an excellent answer which clearly explains both points required and scores two marks.

Question 3 (a)(iii)

Candidates had been well-prepared for this type of calculation which is new to this specification and it was pleasing to see the way that a large number of candidates laid out their answers, although this was not uniformly the case. The use of 'signposting' to indicate the steps in a calculation is to be encouraged.

The point that was missed by the vast majority of candidates was the reference in the question to "produced in each of these experiments" and the precision of the volumes given in the results table. This phrase was meant to direct the candidates to reflect on the apparatus given in the diagram and thus the precision of the volume that could be determined from this apparatus. Sadly this aspect was not appreciated by most and so answers such as 40.3 cm^3 were frequently seen.

This specification does not have chemistry coursework and so assessment of understanding of apparatus and practical procedures has to be a part of the examination papers.

(iii) Calculate, using the Ideal Gas Equation, the volume of hydrogen gas, in **cm^3**, that should be produced in each of these experiments.

[$pV = nRT$ $R = 8.31$ J mol^{-1} K^{-1} $p = 101\,000$ Pa]

(4)

$V = \dfrac{0.00164\ldots \times 8.31 \times 397}{101\,000}$ ~~101 000 101 000~~

~~= 5.376 × 10^-5 m^3~~

~~→ 0.0537... m^3~~

~~= 538 cm^3~~

= 5.38×10^{-5} m^3

~~= 0.538 cm^3~~

= 53.8 cm^3

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Examiner Comments

One mark awarded within the calculation was for the correct conversion of the temperature into Kelvin (K). In this example it is not done correctly and so one mark is not awarded. The more difficult conversion from m^3 to cm^3 however has been done correctly. The final answer has not be given in whole numbers of cm^3 but otherwise the calculation is correct and so two marks were awarded.

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Examiner Tip

Conversion of a number between different units is an important skill that should be practiced and learnt.

(iii) Calculate, using the [redacted]n, the [redacted], that should be produced in each of these experiments.

[$pV = nRT$ $\quad R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$ $\quad p = 101\,000$ Pa]

(4)

$V = \frac{nRT}{P}$ $\quad \frac{0.00165 \times 8.31 \times 297\text{K}}{101\text{kPa}}$

$= 0.0403$

$\times 1000 = 40.3199545$

$= 40.32\text{cm}^3$

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Examiner Comments

The technically correct way to use the ideal gas equation is to use pressure in pascals (Pa) and not kilopascals (kPa) to obtain an answer in m^3 and then to multiply by 10^6 to obtain an answer in cm^3. However the correct final answer can be obtained from dividing by the number of kPa and then multiplying by 10^3 as seen here. The final answer has not been given as a whole number readable by the 250 cm^3 measuring cylinder and so the response was awarded three marks out of four.

Question 3 (a)(i–ii)

These were straight-forward molar calculations which were more akin to the legacy exam papers, but are still within the scope of the new specification in order to enable lower-ability candidates to gain some credit on this type of question. The majority of candidates scored both marks, with even the candidates at the E boundary having a mean of 1.36.

Candidates are advised not to present their final answer as a fraction because of the issue of significant figures. In this particular instance this was not a concern but the practice should not be encouraged.

	Experiment 1	Experiment 2	Experiment 3
Mass of magnesium / g	0.04	0.04	0.04
Volume of hydrogen gas / cm^3	31	25	32

The equation for the reaction is

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

(a) (i) Calculate the number of moles of magnesium used by the student in each experiment.

(1)

$n = \frac{ms}{Mr} = \frac{0.04}{24.3} = 1.64 \times 10^{-3}$

(ii) Use your answer from part (a)(i) to deduce the number of moles of hydrogen gas that should be produced.

(1)

The same due to 1:1 ratio $= 1.64 \times 10^{-3}$

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Examiner Comments

This is an example of where significant figures were penalised but also where transferred error (TE) was also applied.

The answer to part (i) is 0.01646...... and so will round up to 1.65 x 10^{-3} so no mark was awarded for this part. However stoichiometry is a one-to-one molar ratio and so the answer to part (ii) is the same as the answer to part (i). Hence whatever value a candidate gives in part (i) is also the answer to part (ii) which means that TE can be applied here and the mark awarded for part (ii).

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Examiner Tip

This candidate has written the molar formulae in a format that they understand so that these can then be applied for all of this type of question. This can be a useful strategy for answering such questions.

	Experiment 1	Experiment 2	Experiment 3
Mass of magnesium / g	0.04	0.04	0.04
Volume of hydrogen gas / cm^3	31	25	32

The equation for the reaction is

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

(a) (i) Calculate the number of moles of magnesium used by the student in each experiment.
(1)

$n = \frac{mass}{mr}$ $\qquad \frac{0.04}{24.3} = 0.00165$ moles

(ii) Use your answer from part (a)(i) to deduce the number of moles of hydrogen gas that should be produced.
(1)

~~n=cV~~

~~0.0165~~

~~0.00165 moles~~

~~0.0165~~

2 moles

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Examiner Comments

The answer to part (i) is correct and gains the mark. There is a correct answer to part (ii) but it is crossed out and replaced by an incorrect one and so this does not score.

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Examiner Tip

If work is crossed out and replaced then an examiner will ignore the crossed out work. If the answer is not replaced then the examiner will do their best to mark what has been crossed out.

Question 3 (b)

There was considerable confusion in candidates' answers between reliability and accuracy. In addition it was common to see answers that referred to the identification of erroneous results but then did not give a reason or explanation for what should be done with them. In addition repetition does not make the results more precise but rather it allows imprecise results to be identified and then discarded.

At GCSE the use of terminology in scientific investigations is clearly defined and so at this level candidates should continue with this practice. The commonly used illustration of arrows on a target board is a helpful way to explain these points to candidates.

(b) Give a reason why the student repeated the experiment three times.

(1)

Repeating the experiment, improves the accuracy of the results.

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Examiner Comments

Repeating the experiment does not increase the accuracy of the results and so this response does not score.

(b) Give a reason why the student repeated the experiment three times.

(1)

To detect any anomalies (25cm^3)

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Examiner Comments

An example of a response where the detection of errors or anomalies is given but no instruction on what to do. In a subsequent question on titration results the candidates know to omit the outlier from their mean and this approach is required once errors or anomalies are identified.

Question 3 (c)

The question proved to be a good discriminator and tested the candidates understanding of chemistry in a practical setting. This is certainly an area that centres can focus on with their candidates.

The question asked for three reasons and three changes but candidates often just seemed to write everything that they could without structuring their answer appropriately. A number of neutral points were ignored such as any reference to change in temperature or the need to measure the length of magnesium more accurately. However incorrect chemistry was penalised, such as references to "not all of the magnesium reacting" because the question clearly stated that the hydrochloric acid was in excess.

There were four different issues and their associated improvements that were awarded credit and so candidates had ample opportunity to gain credit. The most common correct response seen involved reference to the 'loss of gas' which would have occurred but the improvement frequently suggested was just to 'use a gas syringe' but the replacement of a measuring cylinder with a gas syringe would not be a suitable improvement. The candidates needed to refer to the use of a sealed apparatus such as a conical flask that was then connected to the gas syringe. The size of the measuring cylinder was also often mentioned but the large graduations resulting in an inaccurate reading was poorly expressed.

(c) Give three reasons for the difference between your calculated value in (a)(iii) and the actual volumes of hydrogen gas obtained by the student.

For each reason, identify a change to either the apparatus or the chemicals that could be made by the student to improve the result.

(6)

The magnesium ribbon may have been oxidised by exposure to the air. To prevent this, the magnesium should be stored in an airtight container before use.

The apparatus is entirely closed off, so the production of gas may have increased the pressure. A gas cylinder ~~should be~~ should be used to ensure the volume of gas measured was accurate.

A very small mass of magnesium was used, increasing the percentage uncertainty in the measurement of its mass. A larger mass of magnesium should be used to prevent this.

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Examiner Comments

This is an example of one of the more ably laid-out responses seen with an attempt clearly made to give three reasons and three changes. The first issue of the oxidation of magnesium is a correct one but the improvement suggested is incorrect. Likely the candidate is thinking of the storage of sodium metal but this is not suitable here. The magnesium ribbon is cleaned with 'rough' paper of some description. The second issue is incorrect as pressure is not a concern. The third issue of the small mass is correct and the improvement is also suitable. Hence this response scored three marks.

Question 4 (d)

A useful discriminatory question with the grade A candidates scoring both marks but only the better of the less able candidates able to score one mark. The observation mark required both the colour and state. The mark for the identity of the solutions proved the more challenging and both solutions had to be correct for the one mark to be awarded.

(d) Two of the solutions produce the same result on the addition of dilute nitric acid followed by silver nitrate solution.

State the observation with this test and the **two** solutions that give this result.

(2)

Observation white precipitate formed.

Solutions HCl and Potassium chloride

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Examiner Comments

The observation is correct. The identity of the solutions are also correct as either names or formulae, or both as seen here, were acceptable.

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Examiner Tip

If the name or formula is not explicitly asked in the question then either will be acceptable. However if both the name and formula are given for one substance then both must be correct otherwise it will be a case of the incorrect response negating the correct one.

Question 4 (e)

Part (e) proved to be much harder for candidates to get right than part (d) with even the candidates at the grade A boundary scoring a mean of about 1.5 out of 2.

The ionic equation, as usual, was a key discriminator with only the more able candidates able to select the correct species and to produce a balanced equation.

(e) The hydrochloric acid and the sodium carbonate solution react together. State an observation you would make and write the **ionic** equation for the reaction. State symbols are not required.

(2)

Observation CO_2 given off so it fizzes

Ionic equation

$HCl + NaCO_3 \rightarrow$ ~~$CaCO_3$ + HNA~~

Cl^-

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Examiner Comments

The observation mark was awarded for the reference to "it fizzes". Nothing else was creditworthy.

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Examiner Tip

Carbon dioxide, oxygen or hydrogen gas are not observed and so the comment that "CO_2 given off" does not gain any credit. A suitable observation is bubbles, fizzing or effervescence.

(2)

Observation Effervesons

Ionic equation

$CO_3^{-}(aq) + 2H^+ \longrightarrow CO_2 + H_2O$

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Examiner Comments

The spelling "effervesons" is incorrect but unambiguous and so the mark for the observation was awarded.

Unfortunately this candidate has not checked the balancing of the equation by charge and so the second mark was not given.

Question 5 (a)

Another useful discriminating question where the less able candidates included the outlier in their calculation of the mean, whereas the more able correctly omitted it.

	Titration 1	Titration 2	Titration 3
Final burette reading / cm^3	20.50	40.40	20.00
Initial burette reading / cm^3	0.00	20.50	0.00
Volume added / cm^3	20.50	19.90	20.00

The equation for the reaction is

$$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$$

(a) Select the appropriate titres and calculate the mean titre in cm^3.

(1)

$$\frac{20.50 + 19.90 + 20.00}{3} = 20.1$$

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Examiner Comments

An example of a response where the outlier was incorrectly included in the calculation of the mean and so did not score.

Question 5 (b)

This was the first completely unstructured calculation question on the paper, given that the previous Q3(a)(iii) gave the instruction to use the Ideal Gas Equation. The full range of marks were seen and thus was very discriminatory between different ability candidates, with scores of 1–4 being of similar percentages. The fifth mark proved the most elusive with only 6.6% of candidates gaining full marks. However it was often felt that if the candidates had re-read the question then a number of 4 mark scores would have been increased to 5 marks by either quoting to one decimal place as required in the question, or by adding a statement of the suitability of the use of the acid for the aging of wood.

There was more than one calculation method that could have been used to solve this problem and full credit was given for each method.

(b) Calculate the concentration of the **undiluted** nitric acid in g dm^{-3}. Give your answer to one decimal place.

Deduce whether this nitric acid is suitable for use in artificially ageing wood.

(5)

$\frac{19.95}{1000} \times 0.08 = 1.596 \times 10^{-3}$ moles of sodium hydroxide reacted.

∴ 1.596×10^{-3} moles of nitric acid in 25 cm^3 in each flask.

∴ $1.596 \times 10^{-3} \times 10 = 1.596 \times 10^{-2}$ moles of nitric acid in 250 cm^3 flask.

∴ ~~1.596×10^{-2}~~ mass = moles × Mr ∴ $= 1.596 \times 10^{-2} \times 63$ = 1.00548 g of HNO_3 in 10 cm^3

1.00548 in 0.01 dm^{-3}

∴ $\frac{1.00548}{0.01}$ = 100.5 g dm^{-3} of HNO_3

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Examiner Comments

This is an example of one of the acceptable alternative routes for the calculation and gives the final answer correctly to one decimal place. However there is no comment relating to the suitability, or otherwise, of the acid for use and so the fifth mark was not awarded. Hence this response scored four marks.

(b) Calculate the concentration of the **undiluted** nitric acid in g dm^{-3}. Give your answer to one decimal place.

Deduce whether this nitric acid is suitable for use in artificially ageing wood. (5)

moles of NaOH = 0.08 × 0.01995 = 1.596×10^{-3} moles

~~mol~~ NaOH : HNO_3
1 : 1 moles of HNO_3 = 1.596×10^{-3}

conc. of HNO_3 = $\frac{1.596 \times 10^{-3}}{25 \times 10^{-3}}$ = 0.06384 mol dm^{-3}

Dilute ~~nitric~~ conc. of HNO_3 = 0.06384 mol dm^{-3}

Undiluted conc. of HNO_3 = 0.06384 × 25 = 1.596 mol dm^{-3}

Conc in g dm^{-3} = ~~1.596~~ 1.596 × 63 = 100.548 g dm^{-3}

100.548 g dm^{-3} is very similar to 100 g dm^{-3} so the nitric acid is suitable for artificially aging wood.

ResultsPlus
Examiner Comments

This is an example of the first calculation route given in the mark scheme and this response scores four marks. The fifth mark is not awarded because although there is a comment on the suitability of the acid for use, the question requires the answer to be given to one decimal place and this has not been done.

ResultsPlus
Examiner Tip

Once a response is completed, even if it takes some time, it is always worthwhile re-reading the question to ensure that the answer given does match what is required.

Question 5 (c)

A more challenging dot-and-cross diagram than perhaps many candidates had been used to doing. Responses were possibly centre-specific because the mean at the grade A boundary was only 1.87 but over 12% of candidates scored all three marks.

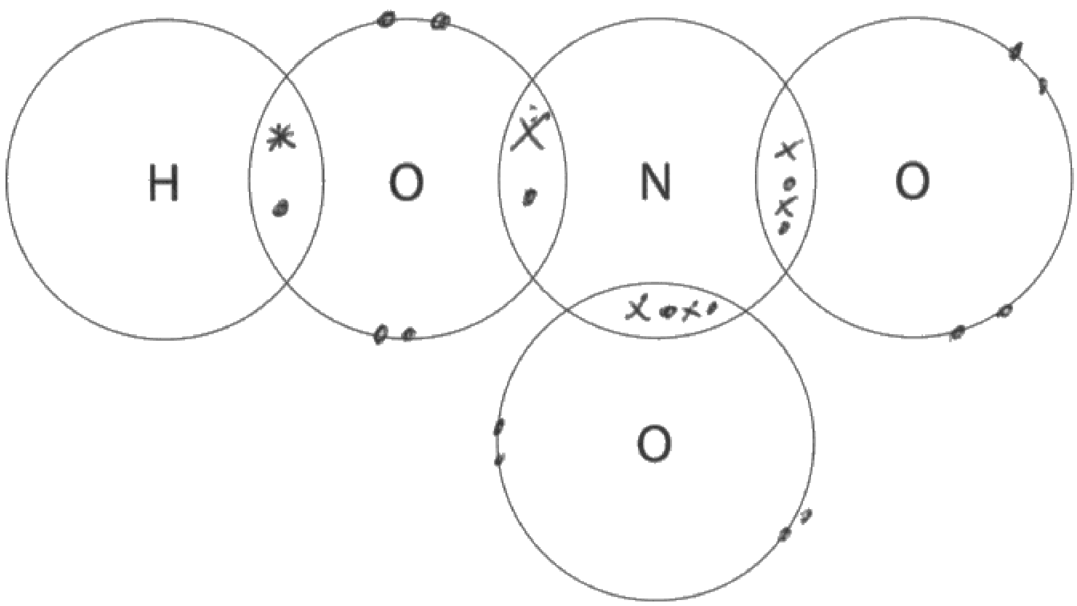
A single, a double and a dative covalent bond were all required for the successful completion of the diagram. There was no evidence of candidate confusion or difficulty over the use of the different symbols for the electrons.

(c) Complete the dot-and-cross diagram for the bonding in nitric acid, showing only outer shell electrons.

Use (•) for the oxygen electrons,

(**x**) for the nitrogen electrons and (✱) for the hydrogen electron.

(3)



ResultsPlus
Examiner Comments

An example of a frequently seen response which scored two marks. One of the oxygen atoms only bonded to the nitrogen atom should have a dative covalent bond to the nitrogen atom. However in this example both of the oxygen atoms bonded solely to the nitrogen atom have double bonds and this satisfies the need for an octet for each oxygen but it expands the octet for the nitrogen atom as it has ten electrons. Since nitrogen is in period 2, the expansion of the octet is not possible due to the absence of d orbitals and the energetic infeasibility of occupying orbitals from a higher energy level.

ResultsPlus
Examiner Tip

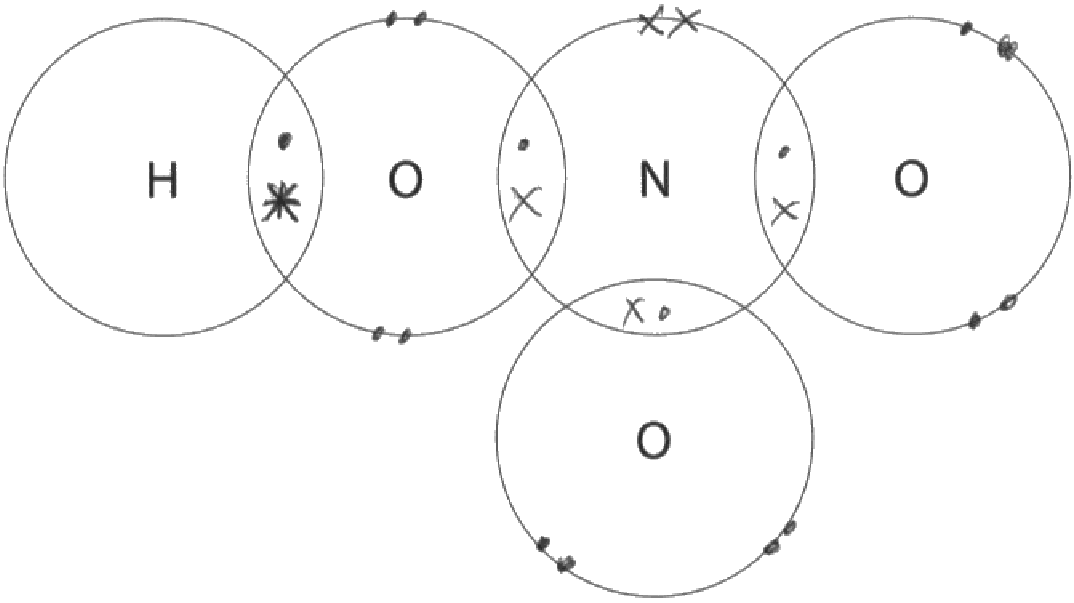
Remember that only elements from period 3 and above can have more than eight electrons in their outer shell.

(c) Complete the dot-and-cross diagram for the bonding in nitric acid, showing only outer shell electrons.

Use (•) for the oxygen electrons,

(**x**) for the nitrogen electrons and (✱) for the hydrogen electron.

(3)



ResultsPlus

Examiner Comments

This is an example of a less able response which only scored one mark for the correct electron arrangement shown for the oxygen atom on the left joined to the hydrogen and nitrogen atoms. The nitrogen atom has electrons but neither of the other oxygen atoms have eight electrons and in fact they are each only given five 'dots' instead of the necessary six.

ResultsPlus

Examiner Tip

It can be useful to write in some space away from the diagram the number of electrons each atom has and then to make sure that this number is used in the dot-and-cross diagram.

Question 5 (d)

Over a third of candidates could correctly calculate the atom economy and these proved to be the more able candidates. Occasionally the mark was lost despite correct working because of incorrect rounding.

(d) One possible method for the formation of nitric acid involves the reaction between dinitrogen tetroxide and water.

$$3N_2O_4 + 2H_2O \rightarrow 4HNO_3 + 2NO$$

Calculate the atom economy for the formation of nitric acid from this reaction.

(1)

$\frac{4}{6} = 0.\dot{6}$

66.66%

ResultsPlus
Examiner Comments

An example of the error that some candidates made is thinking that atom economy is determined by dividing the number of moles.

ResultsPlus
Examiner Tip

Learn the correct expression for atom economy and its significance.

Question 6 (a)

The more able candidates were able to correctly make the necessary two points to explain the bond angles in the two molecules. The mark scheme allowed, in this instance, reference to the lone pairs in the molecules rather than lone pairs on the oxygen in water and on nitrogen in ammonia. The more able candidates did not need this allowance and the quality of their answer was distinctly higher.

6 (a) The diagram shows bond angles in ammonia and water.

Explain why the bond angle in water is less than the bond angle in ammonia.

(2)

Because oxygen has two lone pair which reduce the bond angle by 2·5° each one and ammonia only has one lone pair.

ResultsPlus
Examiner Comments

This response scored one mark for the statement that water has two lone pairs whereas ammonia has one lone pair. There is not a clear explicit comment that the lone pair repulsion is greater than bonded pair repulsion or that the repulsion of two lone pairs is greater than one. The statement is just that the angle is reduced without a reason being given.

ResultsPlus
Examiner Tip

An explanation requires more than a simple statement but includes some justification or reasoning.

6 (a) The diagram shows bond angles in ammonia and water.

Explain why the bond angle in water is less than the bond angle in ammonia.

(2)

the bond angle is less in water than ammonia as there are only 2 hydrogen atoms. They repel each other but as there is less it is by a lower amount.

ResultsPlus

Examiner Comments

This is an example of a response where there appears to be incorrect understanding of the parts of the molecule which repel as it is not the hydrogen atoms but the pairs of electrons that do the repelling. Thus this response scores zero.

Question 6 (b)

The mean for part (c) was actually less than that for part (b) even though more marks were available in total, which illustrates that candidates found this question the harder of the two. Even those at the grade A boundary had a mean of 0.96 and so this proved to be a challenging question for all. Occasionally correct comments about radii were negated by reference to ions. Candidates have a heightened need for care in their choice of words and terms used in this type of question.

pair repulsion is greater than bond pair – bond pair repulsion.

(b) Explain why the O—H and S—H bond lengths are different.

(3)

O-H and S-H have a different bond length because the O-H is a much stronger bond than the S-H and as such has a smaller bond length. The O-H bond length is so small & strong because it has a very electronegative oxygen atom that is strong enough for hydrogen bonding. The oxygen moves the bonding pair of electrons much closer to it making the oxygen δ− and the hydrogen δ+, creating electrostatic attraction. In the S-H bond the electronegativities of the ~~these~~ atoms are very similar so don't have much attraction, making the bond weaker, making it longer.

(Total for Question 6 = 5 marks)

ResultsPlus

Examiner Comments

In this response the common error of attributing the bond length to differences in electronegativity is seen. The score for this response was zero.

(b) Explain why the O—H and S—H bond lengths are different.

(3)

(O-H) bond is shorter because Oxygen has less shielding and atom is smaller which means bond is stronger than in (S-H) bond. (S-H) bond is longer since Sulfur has greater shielding and size of atom is bigger which means distance between nucleus and electron is bigger than in (O-H) bond. So (S-H) bond is weaker bond.

ResultsPlus

Examiner Comments

It is evident from the answer shown here that the candidate has a good level of understanding and due to the reference to the increased shielding and atomic radius of sulphur the S-H bond length increases in comparison to the O-H bond length. This scored two marks. Unfortunately the effect of this, namely that there will subsequently be less attraction for the bonding electron pair, is missing.

Question 7 (a)

Total scores of three or four marks were the most common ones awarded, although this question did cater for the whole ability range. This is not surprising since it was the first of the new style of question with indicative points rather than marking points per se and for structure and lines of reasoning marks. However there was some disappointment over the way that many responses were poorly constructed and expressed.

Only the more able candidates commented on the fact that the effect of the increased nuclear charge of barium is negated or outweighed by the increased shielding and distance effects.

A small but significant number of candidates commented in general terms about trends down a group rather than specifically referring to barium and strontium as was requested in the question. This was penalised and candidates should always carefully answer the question given rather than one of their own.

$Sr + 2H_2O \rightarrow Sr(OH)_2 + H_2$

7 *(a) A student suggested that the difference in the rates of reaction of strontium and barium with water is due to the difference in the sum of their first and second ionisation energies. Discuss this suggestion.

(6)

- $Sr + 2H_2O \rightarrow Sr(OH)_2 + H_2$
- $Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$

- Barium is lower in the group group 2, therefore has more electron shielding and a larger atomic radius. Therefore its first ionisation energy (the energy required to remove 1 electron from 1 mole of an atom in its gaseous state) is less than Sr which has a shorter atomic radius and less shielding.

- Rate of reaction is also faster in Ba as its outer electrons are lost more easily, it is oxidised

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ResultsPlus

Examiner Comments

This example makes four of the indicative points, namely: the sum of ionisation energies for barium is lower, barium has a bigger atomic radius, the barium nucleus has more shielding and that barium has a faster rate of reaction. These four indicative points warranted three marks and then one additional mark for partial structure and some lines of reasoning.

7 *(a) A student suggested that the difference in the rates of reaction of strontium and barium with water is due to the difference in the sum of their first and second ionisation energies. Discuss this suggestion.

(6)

This could be true because as you go down group 2, ionisation energy decreases, meaning the energy required to remove the outer most electrons, so therefore when ~~dissolving~~ reacting in the water, barium will react more vigorously due to the fact that it can give up its electrons easier. However, this may not be true because barium may react more vigorously with water due to the fact that the barium metal has a lower charge density than strontium / are packed less tightly in the metal, allowing for water to react faster with more barium atoms within the metal.

ResultsPlus
Examiner Comments

This is a less able answer that scores only two marks. The indicative points made are that barium loses its outer electrons easier and reacts faster, which with partial structuring and some lines of reasoning results in a score of two marks.

ResultsPlus
Examiner Tip

Avoid repeating the same point and also avoid repeating any statement given in the question.

Question 7 (c)

This question also proved very discriminatory with the full range of marks awarded, albeit only a small minority of the most able candidates able to gain the fourth mark. The candidates at the lower boundary tended to score one mark or zero, while those at the 'top end' scored either two or three marks. A common error was the failure to refer to 'ions' by only referring to atomic radii.

(c) Explain why magnesium nitrate, $Mg(NO_3)_2$ decomposes more readily on heating than potassium nitrate, KNO_3.

(4)

Magnesium ions have a 2+ charge and a small ~~atomic~~ ionic radius, meaning they have a greater charge density than potassium ions (which are larger and have a 1+ charge). This means magnesium ions can distort the nitrate ions more, ~~which~~ weakening the bonds. This ~~means the~~ means less ~~energy~~ heat energy is required to break the bonds in magnesium nitrate, so it decomposes more readily on heating than potassium nitrate.

ResultsPlus

Examiner Comments

This is clearly the work of an able candidate and scores three out of four marks. The fourth mark is for the weakening of the bonds in the nitrate ion. In this response there is reference to weakening of bonds but it is not clear which bonds are meant and it was evident from other scripts that oftentimes candidates thought that the ionic bond between the cation and anion were affected. Hence if there was no explicit mention of the type of bonds being weakened then the fourth mark was not awarded.

ResultsPlus

Examiner Tip

Take care to make clear and unambiguous reference to the type of bonds referred to.

(c) Explain why magnesium nitrate, $Mg(NO_3)_2$ decomposes more readily on heating than potassium nitrate, KNO_3.

(4)

Potassium ~~Magnesium~~ has a much higher ~~smaller~~ electron density. This means that the larger Potassium ion will pull the Nitrate ion with greater force. This means it cannot be as easily decomposed due to the pull by the nucleus. Magnesium is smaller and has a smaller electron density meaning its hold on the nitrate ion is not as strong.

ResultsPlus

Examiner Comments

This is an example where confusion between charge density and electron density is apparent. These are different terms and electron density is not appropriate because the two variables are conflicting, namely the potassium ion has more electrons than magnesium but over a larger volume. Without access to the figures involved it is not possible to come to a correct conclusion.

ResultsPlus

Examiner Tip

Exercise great care in the use of similar sounding terms but that mean quite different things and are not equivalent.

Question 7 (d)

The diagrams seen of the experimental apparatus in part (i) certainly left a lot to be desired. They did raise the question whether the candidates had actually done any practice in drawing such apparatus and indeed whether they had done or seen a similar practical. However it is noted that while there is no core practical of this activity, the specification does state that student should understand "experimental procedures to show". The removal of coursework assessment and the emphasis on practical in examinations should encourage centres and their candidates to practice such activities.

An example of the total lack of appreciation of the task required was when a heated crucible was drawn with no attempt, practical or otherwise, at collecting any gas that could be evolved. In addition a number of candidates 'lost track' of where they were in the question or went into 'autopilot' by adding hydrochloric acid to the carbonate rather than heating it.

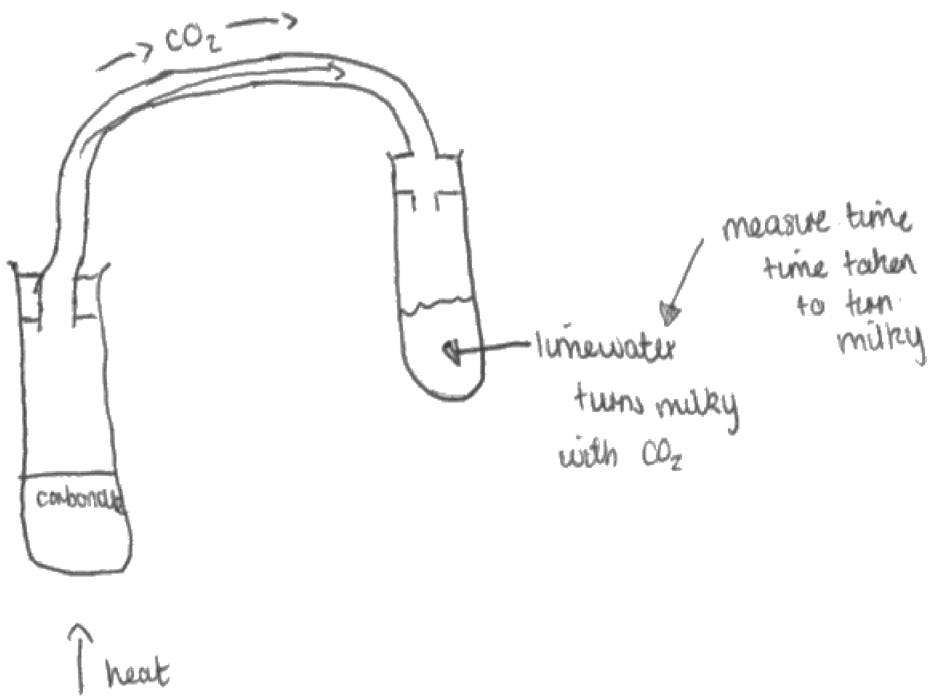
In part (ii) few correctly referred to the Bunsen setting or distance from the test-tube, with the most common error being the use of the 'same mass' which although would still work to show the difference it does not answer the question of how to ensure a fair test.

The question in part (iii) asked for data that could be used to make a comparison and a number of less able responses simply stated "the time it takes for the carbonate to decompose" which fails to either give a comparison or how the decomposition would be evident.

(d) Some metal carbonates also undergo thermal decomposition.

(i) Draw a diagram of the apparatus that could be used to compare the ease of thermal decomposition of lithium carbonate, Li_2CO_3, and magnesium carbonate, $MgCO_3$.

(2)



(ii) State **one** way in which you would ensure a fair test.

(1)

use the same mass of each carbonate

(iii) State how data obtained in this experiment could be used to make a comparison.

(1)

the time taken ~~was~~ for the limewater to turn milky will indicate when CO_2 was produced which shows thermal decomposition so the faster the time, the easier the decomposition

ResultsPlus
Examiner Comments

The diagram in this response is an illustration of one of the errors mentioned above, namely that the tube with the limewater is sealed and so there is no way for the gas to escape. The bung/cork in the top of the test-tube with the carbonate would clearly allow the gas to escape and so scored one mark for part (i).

This response also has the common error of "same mass" of carbonate in part (ii) which did not score, however the mark was awarded for part (iii).

ResultsPlus
Examiner Tip

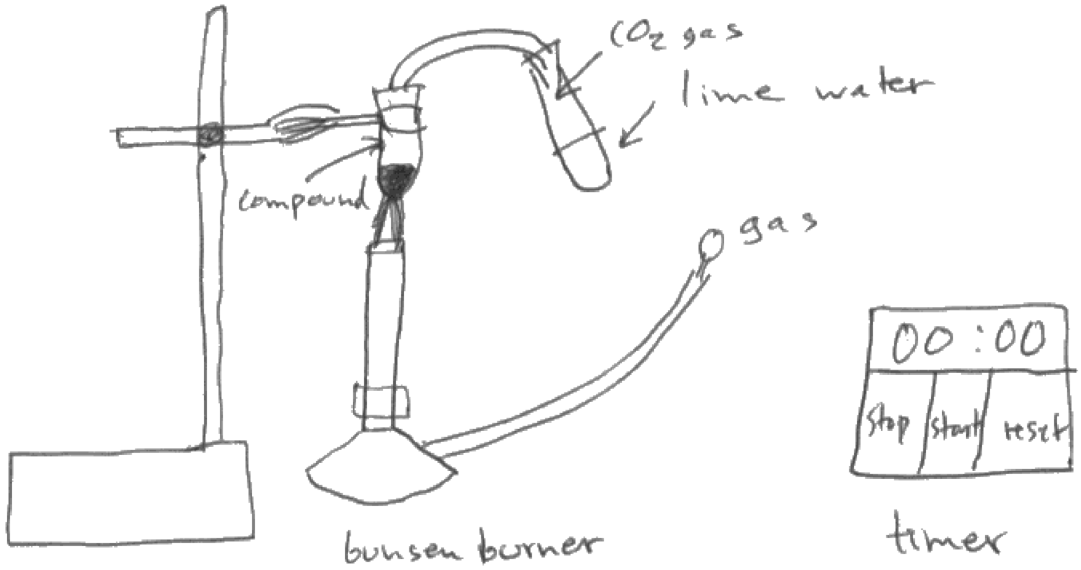
Practice drawing experimental or practical apparatus and make sure that it will achieve its purpose.

more energy is needed to decompose KNO_3.

(d) Some metal carbonates also undergo thermal decomposition.

(i) Draw a diagram of the apparatus that could be used to compare the ease of thermal decomposition of lithium carbonate, Li_2CO_3, and magnesium carbonate, $MgCO_3$.

(2)



(ii) State **one** way in which you would ensure a fair test.

(1)

Use the same height from bunsen flame. From the tip of the flame to the bottom of the boiling tube with the same height.

(iii) State how data obtained in this experiment could be used to make a comparison.

(1)

Measure time taken for each compound to decompose. ~~&~~ Measure time taken for lime water to turn cloudy ~~an~~ for each Gp1 and Gp2 and compare.

ResultsPlus
Examiner Comments

The diagram in part (i) also illustrates another common error in that there appears to be a solid bung/cork in the test-tube with the carbonate and so there is no way for the gas to escape. In addition the delivery tube seems to be going into a sealed test-tube, although the drawing is rather unclear.

Both parts (ii) and (iii) scored the marks for suitable answers.

Question 8 (b)(i)

Empirical formulae calculations are generally high-scoring questions and this was the case here. However there remain the common errors seen on previous specifications, see below, and which candidates need to avoid.

(b) Sulfur reacts with fluorine to form a number of different compounds.

(i) One compound contains 45.79% sulfur and 54.21% fluorine by mass. Calculate the empirical formula of this compound. **(2)**

$\frac{45.79}{32.1}$ $\frac{54.21}{19}$

13.69 2.853…

S_5F

ratio is 5 : 1

ResultsPlus
Examiner Comments

This is a rather unusual example but one which illustrates the need to double-check working. The correct division is laid out initially but the answer to 45.79/32.1 is clearly wrong and surely could have been quickly spotted on review. This incorrect intermediate answer gives a wrong final empirical formula and this response scored zero.

ResultsPlus
Examiner Tip

Always double-check calculations throughout to eliminate any relatively straightforward errors.

(b) Sulfur reacts with fluorine to form a number of different compounds.

(i) One compound contains 45.79% sulfur and 54.21% fluorine by mass. Calculate the empirical formula of this compound. **(2)**

	S	F
mass	45.79	54.21
mr	28.1	19
	$\frac{1.63}{1.63} = 1$	$\frac{2.853}{1.63} = 1.75$

4 : 7

S_4F_7

ResultsPlus
Examiner Comments

An example of a response where the incorrect relative atomic mass was used and that resulted in zero marks.

ResultsPlus
Examiner Tip

Always double-check that the data used is the right data.

Question 8 (b)(ii–iii)

This question was another effective discriminator with a very good spread of marks across the whole ability range. Generally redox appears to be a concept that is well-understood.

One point to highlight is that the question required the oxidation numbers of 'all' of the atoms, with 'all' in bold. A significant number of candidates omitted reference to the fluorine, presumably because the oxidation number didn't change, but this was required and so its absence was penalised. However a number of candidates 'rescued' the mark by annotating the equation above with the respective oxidation numbers.

(ii) In a dry container, a fluoride of silver reacts with sulfur to produce disulfur difluoride. Complete the equation for this reaction.
State symbols are not required.

(1)

$$S_8 + 8AgF_2 \rightarrow 4\,S_2F_2 + 8\,AgF$$

(iii) Explain, by using the oxidation numbers of **all** the atoms, whether or not this is a redox reaction.

(3)

Sulphure = 0 → +1

Silver = +2 → +1

F = -1 → -1

This is redox as sulphur has lost an electron but and silver has gained an electron

ResultsPlus
Examiner Comments

The stoichiometry in the equation in part (ii) is messy but correct. Candidates do need to make sure that examiners can clearly decipher their work.

The oxidation numbers given in (iii) are all correct but there is no mention of oxidation or reduction which is expected when explaining whether a reaction is a redox reaction or not.

ResultsPlus
Examiner Tip

Use the terms of reduction and oxidation with their associated equations when justifying whether a reaction is redox or not.

(ii) In a dry container, a fluoride of silver reacts with sulfur to produce disulfur difluoride. Complete the equation for this reaction. State symbols are not required.

8r

(1)

S_8 + ...8....AgF_2 → ....4....S_2F_2 + ...8....AgF

~~8 10 5 12 6~~ ~~4 6 12 8~~

(iii) Explain, by using the oxidation numbers of **all** the atoms, whether or not this is a redox reaction.

(3)

The oxidation no. of S_8 is 0, the oxidation no. of ~~so~~ sulphur in S_2F_2 is +2, The oxidation number of Ag in AgF_2 is +2 ~~to~~, in AgF it is a +1 ~~g~~. The oxidation number of fluorine is -1 in AgF_2 and -1 in AgF, so sulphur was oxidised and silver was reduced hence it is an oxidation reaction.

ResultsPlus
Examiner Comments

An example of a response which includes the error of attributing the oxidation number +2 to sulphur in S_2F_2. There is no working shown and this may have contributed to the error because the candidate correctly gives the fluorine an oxidation number of -1 so the sulphur has to be +1. Otherwise the response is correct and scores one mark for the equation and two marks for the oxidation numbers.

ResultsPlus
Examiner Tip

Writing oxidation numbers down as a sum can help to eliminate errors.

Question 8 (c)

This was a very straightforward question requiring candidates to also draw on their GCSE knowledge and understanding with the result that marks of three or four out of four were the most common ones awarded. There was no evidence that the candidates had 'run out of time' at the end of the paper and so these marks were as equally accessible as all the others on the paper.

There continues to be the use of the term 'free' electrons rather than 'delocalised' and this former term is not creditworthy at this level. A small number of candidates also spoilt their answers by referring to intermolecular forces.

(c) Element **X** has the typical appearance of a metal.

Predict **two** other distinct physical properties that element **X** would exhibit if it is a metal. Explain your choices in terms of structure and bonding.

(4)

X would conduct electricty due to it's sea of delocalised electrons being able to carry an electronic current.

X would have a high ~~melt~~ melting tempreture due to it's strong metallic bond.

ResultsPlus
Examiner Comments

The explanation for the high melting temperature given here is insufficient at this level.

ResultsPlus
Examiner Tip

The number of lines provided for the answer does help to give some indication of the depth or quality of the answer expected.

Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- Practical work is a greater component of the examination questions due to the removal of coursework and thus needs greater emphasis in teaching, which should include the drawing of practical equipment and an understanding of its use.
- Calculations are largely unstructured and thus considerable practice is required by candidates so that they can demonstrate their true ability, with emphasis on clear 'signposting' during their working.
- The phrase "to an appropriate number of significant figures" is an important one because it provides candidates with the opportunity to show that they understand the relevance of the numbers used and from the piece of equipment that they are obtained. This can be supported from the precision of the data given in the question.
- The correct use of appropriate terminology is important if maximum credit is to be achieved as the use of incorrect terms or the 'sloppy' use of correct terms can negate otherwise good chemistry. Particular care is needed with such terms as accuracy, precision and reliability.
- Practice is needed at the longer type comprehension answers in order to enable candidates to construct a coherent and well-reasoned response.
- The maxim 'RTQ^2' or "Read the Question Twice" is a good one for candidates so that they ensure that their answers are focused on the relevant areas.
- If candidates apply these lessons and others emphasised above then they can be confident that their examination score will correctly reflect their true ability.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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