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ASSESSMENT and QUALIFICATIONS ALLIANCE

## General Certificate of Education

# Chemistry 5421

## CHM1 Atomic Structure, Bonding and Periodicity

# Report on the Examination

*2009 examination – January series*

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*Dr Michael Cresswell Director General.*

## General Comments

As this is now a legacy paper, no Year 12 candidates were present in the cohort. Clearly, this had a significant effect on the distribution of ability within the cohort sitting this examination. From the quality of the work seen by the examiners, it was clear that some very able candidates had taken the opportunity to repeat this module and very few poor scripts were seen.

The many excellent answers showed that most candidates had taken the time and trouble to acquire a thorough knowledge and understanding of the chemistry covered in this module. It was clear that very few candidates had failed to prepare themselves adequately for the examination; however, a small minority did struggle with some parts of the paper. All marks were found to be accessible and the majority of candidates were able to complete the examination. Those candidates who were not able to complete the exam tended to be those who wrote unnecessarily long answers or who were inadequately prepared.

The problems with poorly learned definitions, reported in previous years, were very much less evident this year. Most candidates had taken the time and trouble to familiarise themselves with such points. However, in some instances, particularly in question 5, the less-well prepared candidates still tended to use words such as *atoms*, *ions* and *molecules* as if they were interchangeable. It was pleasing to see that most candidates coped well with the reactivity of Group II metals in question 5(c), a distinct improvement on previous years.

The numerical question was, in the main, very well answered, although some candidates chose to calculate the molecular formula directly from the $M_r$ value and then omitted to deduce the empirical formula.

As reported many times previously, some candidates lacked the ability to write concise and relevant answers to questions requiring explanation or description. This resulted in disjointed and rambling accounts, particularly for question 5. Unfortunately, in some cases, comments made in one part of an answer contradicted valid points made elsewhere in the answer, and so marks were lost. This tended to occur mainly in question 5, where some good descriptions of the bonding and structure in metals were spoiled by references to intermolecular forces, molecules etc.

### *Question 1*

Most candidates correctly identified the electron gun but only a small proportion drew an acceptable path for the higher *m/z* isotope. In many cases, the path drawn showed an increased deflection for the $^{88}Sr^+$ ion. Also, many of those candidates who did predict a decrease in deflection for the $^{88}Sr^+$ ion drew paths which were inappropriate.

While some good answers to part (b)(ii) were seen, many candidates simply stated that the $^{88}Sr^+$ ion was *heavier*, or *contained an extra neutron* compared with the $^{87}Sr^+$ ion, rather than relating the difference in their deflected paths to differences in their *m/z* values, and the effect that this difference would have, in the same magnetic field, on the extent of deflection of each ion.

In part (c), while most candidates suggested that the strength of the magnetic field should be changed, some failed to state that the field should be *increased* in order to allow the $^{88}Sr^+$ ion to be *deflected onto the detector*. Part (d) was, generally, well answered, although a few candidates gave their answers to more than the ***one*** *decimal place* stipulated in the question. Very few incorrect approaches, or arithmetical errors, were seen. While most candidates identified the ‘s’ block, a significant minority offered unconvincing explanations. Some candidates identified the block to be ‘p’ or ‘d’.

### *Question 2*

Overall, this question was very well answered. The calculations were, in the vast majority of cases, clearly explained and accurately performed. The units quoted for each final answer were almost invariably correct.

A significant proportion of candidates experienced difficultly in predicting the bonding in ethyne. Frequent errors included structural formulae or dot-and-cross diagrams carrying lone pairs, a single electron or two hydrogen atoms on each of the carbons. A higher proportion of candidates than in previous examinations had correctly learned the definition of *empirical formula*; however, errors were still quite common.

Part (f) was well answered, although a small number of candidates used the atomic number of bromine, rather than its $A_r$ value in their calculation, or confused bromine (Br) with boron (B). Of those candidates who chose to calculate the molecular formula directly from the $M_r$ value of 215.8, some omitted to deduce the empirical formula for compound **B** and so lost a mark.

### *Question 3*

Most candidates found this question to be the most difficult on the paper. In part (a), some good answers were seen; however, many candidates failed to focus their answers on the *movement of particles* in (a)(i) and on *positioning of particles* in (a)(ii). Some candidates couched their answers to (a)(ii) in terms of the motion of particles rather than their positioning; while others simply referred to there being more order or structure in liquids than in gases.
In order to answer part (b) successfully, candidates needed to describe the heat energy change as the energy required to overcome the attractive forces between particles. Some candidates did this, but the majority simply explained the boiling process, or the temperature changes as a liquid is heated until it boils. Some candidates stated that there was no heat energy change during boiling, as the temperature remains constant; others stated that heat is evolved in boiling, or that bonds needed to be broken so that the particles could vaporise.

The definition of electronegativity was generally well known, but the explanation for the absence of hydrogen bonding in $H_2S$ tended to be limited to a reference to the lower electronegativity value of sulphur compared to that of oxygen. The concept that the electronegativity difference between sulphur and hydrogen is too small to generate hydrogen bonding was understood by only a minority of candidates. In part (c)(iii), it was necessary to emphasise the magnitude of the difference in intermolecular forces present in $H_2O$ and $H_2S$ in order to explain why the boiling point of $H_2S$ *is so much lower than* that of $H_2O$; many candidates failed to do this.
Parts (c) and (d) were well answered, with full marks being earned by a higher proportion of candidates than in previous years. Those errors reported previously, such as missing partial charges, incorrect number of lone pairs and hydrogen bonds which fail to link a hydrogen atom with a lone pair were seen, but less frequently than has been the case in the past.

### *Question 4*

Overall, this question was very well answered, and full marks were frequently awarded. Most candidates correctly described the bond type as being dative due to both bonding electrons being supplied by a single atom; however, in some cases, candidates omitted to specify carbon as the donor atom. Most candidates drew acceptable shapes for the two species but a minority assigned two lone pairs to the methylene molecule and one lone pair to the carbocation. The names of the shapes of these species were quite well known, although *tetrahedral* and *distorted tetrahedral* were sometimes seen. The bond angle was well known.

### *Question 5*

Overall, this question was quite well answered; however, part (a)(i) caused problems to a significant number of candidates. While many candidates correctly described iodine as having a regular lattice in which covalently bonded $I_2$ molecules are held in place by van der Waals' forces, it was quite common for answers to be spoiled by references to ionic bonding and macromolecular structures. Having made such errors in part (a)(i), many candidates then, perversely, correctly described the trends in electron number and strength of van der Waals' forces in part (a)(ii).

Most candidates coped well with explaining the trends in melting point and conductivity across the metals of Period 3. Explanations were, in the main, lucid and convincing. Although some candidates did spoil their answers by inappropriate comments such as references to *van der Waals' forces*, *ionic bonding* or *molecules*; the incidence of such errors was much lower than has been the case in previous examinations. In many cases, failure to provide a convincing description of metallic bonding was all that prevented the full 6 marks being awarded. Some candidates misinterpreted the rubric of the question and gave descriptions of the trends across the whole of Period 3, rather than restricting their explanations to the three metals. Where it was clear which comments referred to which elements, the non-metal comments were ignored and marks were awarded on merit. These candidates will have wasted time however.

The trend in reactivity with water of the Group II metals was well known and many candidates scored well in part (c). While errors were much less frequent than in previous years, some candidates failed to balance the barium equation, while others wrote equations showing similar products. Very few candidates struggled with this part.