

GCE

Chemistry A

Advanced Subsidiary GCE **AS H032**

OCR Report to Centres June 2016

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This report on the examination provides information on the performance of candidates which it is hoped will be useful to teachers in their preparation of candidates for future examinations. It is intended to be constructive and informative and to promote better understanding of the specification content, of the operation of the scheme of assessment and of the application of assessment criteria.

Reports should be read in conjunction with the published question papers and mark schemes for the examination.

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H032/01 Breadth in chemistry

General Comments:

H032-01 is one of the two AS examination units for the new revised AS examination. The breadth paper is the first for many years to have included multiple choice questions for assessment. Other significant changes were the inclusion of a greater proportion of mathematics, the assessment of some practical skills, notably analysis, evaluation and planning, and a linear mode of assessment in which all the content is examined together.

Most candidates had prepared well for the examination and tackled all parts of the paper. The standard of difficulty was appropriate, with most candidates achieving over 40% and the high achievers obtaining percentages in the 80s or 90s.

Candidates coped well with chemical calculations but less well with practically based questions, particularly questions involving evaluation of practical procedures, as found in parts of question 22.

There was no evidence that any time constraints had led to a candidate underperforming .

Comments on Individual Questions:

Section A: Multiple choice questions (Q1–Q20)

Overall the multiple choice questions catered for the full range of ability and allowed for good differentiation.

Questions 1, 5, 7, 10, 12, 13, 14, 17, 18, 19 and 20 were generally scored well.

Questions 3, 4, 6, 9, 11 and 15 were poorly answered and often incorrect.

Further comments are shown below:

Q2 – Distractor D was a common incorrect answer.

Q3 – Many candidates were unable to identify the correct molar ratio, with B being a common incorrect answer. Many candidates chose C rather than D, overlooking oxygen in the equation.

Q4 – Candidates were clearly unsure on how to classify a neutralisation reaction, with D being a common incorrect answer.

Q6 – Less able candidates did not consider that orbitals fill singularly and simply chose B as half of 14, the number of electrons in a silicon atom.

Q8 – B and C were common incorrect answers

Q9 – Many candidates did not take into account the trend across periods, with A being a common incorrect answer.

Q11 – This question demonstrated a lack of practical skills with a many candidates unable to identify the false positive caused by the sulfate ion – the discriminator C was a common incorrect answer. This question proved to be the most difficult multiple choice question.

Q15 – Candidates struggled with this very different polarity question. The majority of candidates are clearly used to applying symmetry to much simpler molecules.

Q16 – B was a common incorrect answer with the sigma bond not counted as part of a double bond.

Section B

Question 21

Q21(a) Most candidates identified that different isotopes had the same number of protons but then omitted electrons. The different number of neutrons was usually seen although sometimes atomic mass was shown instead.

Q21(b)(i) This part was mostly correct. Low-scoring candidates sometimes produced errors in averaging or rounding. Most final answers were given to the required two decimal places.

Answer = 63.62

Q21(b)(ii) This part was generally well answered with most candidates processing the data correctly. Candidates sometimes failed to consider 84% or rounded incorrectly in places.

Answer = 3.97×10^{22} atoms

Q21(c)(i) This part was surprisingly poorly answered. Common errors included incorrect formulae for nickel(II) oxide and HNO_3 , and H_2 shown as a product instead of H_2O .

Q21(c)(ii) Most candidates attempted this novel '*dot-and-cross*' diagram. Many candidates correctly showed the bonding electrons around the central nitrogen atom. The remaining electrons around the oxygen atoms proved to be more difficult, with many omitting to show the 'extra electron'.

Question 22

Q22(a) Many candidates were able to calculate the empirical formula of the hydrated salt. While the majority went on to show the formula as $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ to score all three marks, a significant minority failed to convert 12 H and 6 O into $6\text{H}_2\text{O}$.

Q22(b)(i) This part was poorly answered. Candidates rarely seemed to understand the relationship between the precision of the balance and the uncertainty in taking two readings – hence 0.86%, half of 1.72%, was a common error.

Answer = 1.72%

Q22(b)(ii) Correct answers suggested using a larger mass of the salt or a more accurate balance with more decimal places. Many responses instead discussed repeating the experiment and taking an average, or using a lid.

Q22(b)(iii) This was a good question to distinguish practical ability. Many candidates suggested simply 'heating for longer' or 'until no further colour change' but didn't link this to the idea of heating to constant mass.

Q22(c) This part was answered well with the majority of candidates scoring all 3 marks. Where a mark was lost, it was generally either incorrect use of the mole ratio, or incorrect use of the moles of H_2SO_4 to calculate concentration. It was good to see how well many candidates were able to tackle an unstructured titration calculation.

Q22(d) A good proportion of candidates were able to achieve the 2 marks here. A minority correctly identified the elements, but not the oxidation numbers. Aluminium was credited more often than hydrogen, perhaps as only some of the hydrogen atoms are reduced. Some amazing

oxidation states were claimed for S, O, Al and H with more electrons lost than the atoms had. Very few candidates assigned the oxidation and reduction incorrectly.

Question 23

Q23(a)(i) This part was generally answered well showing a good understanding of electron configuration. When incorrect, it was usually for giving the configuration of a bromine atom rather than a bromide ion, or the subtraction of an electron rather than addition giving $4p^4$.

Q23(a)(ii) Most candidates identified that chlorine was the more reactive element, although a significant number responded in terms of electronegativity. More commonly, it was the equation that was incorrect, usually unbalanced or with bromine reacting instead of chlorine.

Q23(b) Most candidates scored this mark by stating a benefit (usually 'kills bacteria') and a risk (usually 'toxic' or 'forms carcinogenic compounds'). Vaguer terms such as 'harmful', 'can make you ill', etc, were not credited.

Q23(c)(i) Most candidates responded correctly with either the name of the reagent: silver nitrate, or its formula: AgNO_3 .

Q23(c)(ii) The colours of the silver halide precipitates were well known and very few candidates failed to score here. Where mistakes were made, it was to put the three colours in the wrong order or to show the colours of halogens in solution.

Question 24

Q24(a) Although similar in style to unstructured direct enthalpy calculations on the legacy specification, this question was harder for two reasons. Firstly, two volumes of 50 cm^3 had to be added together to generate m as 100 g for $mc\Delta T$. Secondly, candidates were asked to quote their final answer to an 'appropriate' number of significant figures. This will be the least accurate measurement (to 3 significant figures in this example).

Many incorrect answers used m as 50 g or quoted a final numerical value to more than 3 significant figures.

Even after obtaining a correct final value for ΔH , this was often not given a negative sign to indicate the exothermic change.

It is important for candidates to show clear working so that markers can see what is intended and able to apply credit using error carried forward.

Answer: $\Delta H = -58.5 \text{ kJ mol}^{-1}$

Q24(b) Only the best candidates were able to construct the required equation. Even when written correctly, state symbols (asked for in the question) were often omitted or shown incorrectly. Although very similar to the ionic equation for formation of silver halides, this equation was beyond most candidates at this stage of their chemistry studies.

Q24(c) This part was well attempted with many candidates able to score at least one of the two marks. Errors related to use of an incorrect mole ratio, applying 10% incorrectly, or ignoring 10% altogether.

Answer: 3.30 mol dm^{-3}

Question 25

Q25(a) This longer answer was answered very well with the majority of candidates able to score 4 or 5 marks. Most candidates explained how the position of equilibrium shifts in response to low temperature and high pressure. The commonest omission was the link between low temperature and a slow reaction rate.

Q25(b) Given that K_c is new to AS level in the reformed specification, this part was attempted well. However, writing a correct K_c did cause problems for weaker candidates, who sometimes inverted the expression, used the + sign from the equation, obtaining a denominator of $[\text{SO}_2]^2 + [\text{O}_2]$, or omitted the square from $[\text{SO}_2]^2$ and $[\text{SO}_3]^2$.

Some excellent answers were seen and this part differentiated very well between candidates of different abilities.

Answer: $[\text{SO}_3] = 0.876 \text{ mol dm}^{-3}$

Question 26

Q26(a)(i) This part was answered very well. Most candidates identified Compound B as a member of the alkenes and showed the correct general formula of C_nH_{2n} .

Q26(a)(ii) A surprisingly large number of candidates answered this part poorly. Many candidates identified either hydrogen or nickel, but not both. Other common errors included steam and H_3PO_4 . This was an easy question and the incorrect answers reflected that many candidates had not learnt organic reagents and conditions for the reactions in the specification.

Q26(b) This part was answered well. If a mark was lost, it was almost always due to compound C, especially at the low scoring end of the range. Many struggled with the structure of a tertiary alcohol or omitted H atoms from the structure.

Compound D was generally drawn correctly by candidates of all abilities. If the mark was not credited, it was usually due to not removing the double bond, or drawing more than one repeat unit.

Q26(c)(i) This part was answered well by most candidates. Some candidates however wrote the molecular rather than the empirical formula, or attempted to show the empirical formula as $\text{C}_2\text{H}_4\text{OH}$ instead of $\text{C}_2\text{H}_5\text{O}$.

Q26(c)(ii) This demanding part was answered poorly by weaker candidates and was good for differentiating higher ability candidates. The mark scheme allowed some credit for using a hydrogen halide to obtain a monosubstituted haloalkane for compound E. Surprisingly, reaction mechanism names were often given instead of reagents. Many candidates seemed to guess, sometimes showing the same reagents for both stages in the hope of getting a mark. Many showed an intermediate containing no halogen atom.

H032/02 Depth in chemistry

General Comments:

H032-02 is one of the new AS examination units for the new revised AS examination. The depth paper contains a number of short answer questions and two longer questions where level of response marking replaces the traditional points based marking schemes. Within this paper candidates are tested on their mathematical ability, the practical skills of planning, implementing, analysing and evaluating and their knowledge and understanding of the material covered across the four teaching modules.

Most candidates had prepared well for the examination and tackled all parts of the paper. The standard of difficulty was appropriate, with a good proportion of the candidates scoring above 80%.

Candidates coped well with calculations, less well with some of the more descriptive questions and poorly with questions that required the description of an experimental technique or the evaluation of a practical procedure.

There was some evidence to suggest that candidates coped better with the topics that had been part of the legacy specification and less well with those topics which were new.

Comments on Individual Questions:

Question 1

Q1(a)(i) This part was generally answered well showing a good understanding of electron configuration. Candidates frequently used subscripts rather than superscripts for denoting the number of electrons in a particular sub-shell and although this was still credited the correct use of notation should be emphasised in lessons.

Q1(a)(ii) Most candidates understood that oxidation resulted in the loss of electrons although some answers considered changes in oxidation number. A significant number of candidates did not specify how many electrons were lost when magnesium was oxidised preventing the award of the mark.

Q1(b) The equation for the second ionisation energy of strontium proved no difficulty for the most able candidates who provided both the correct state symbols and charges. It was surprising however that 40% of candidates failed to score what was meant to be a straightforward mark.

Q1(b)(ii) This descriptive question was well answered with the vast majority of candidates picking up two of the three available marks. Where a candidate scored two marks it was often due to the omission of any comment about the reduction in attraction between the nucleus and the electron as the group was descended. A common error was to discuss the reduction in nuclear charge rather than nuclear attraction.

Q1c(i) Clearly candidates were not expecting to be asked about how to set up the apparatus to measure the volume of a gas produced in an experiment. The specification states that candidates can be assessed on the techniques and procedures required during experiments requiring the measurement of mass, volumes of solutions and gas volumes. Many diagrams were unlabelled or suggested apparatus that was totally unsuitable for the set task. Some provided unsealed systems which would lead to gas being lost which would be inappropriate.

Q1c(ii) On the whole candidates were able to carry out this calculation to a satisfactory conclusion obtaining the relative atomic mass of the unknown metal and then suggesting that this was calcium. With an increased emphasis on the mathematical requirements within the specification, it is important that candidates are aware of suitable rounding within answers. A rounding error in the first part of this calculation frequently resulted in the atomic mass being calculated as 40.5 which did not gain credit. Although the mark for locating the metal as calcium was still awarded as an error carried forward.

Answer = 40.1

Q1(d) This question was not well answered. Most candidates did not specify that there would be fewer moles of the metal. Many candidates were unable to grasp the concept that the amount of substance was linked to mass and relative atomic mass and that a larger atomic mass would lead to a smaller number of moles of the metal and hence a decrease in the volume of hydrogen produced.

Question 2

Q2(a) It is pleasing to see that the vast majority of candidates were able to use the terms London forces or induced dipole–dipole interactions rather than van der Waals as used in the legacy specification. Unfortunately, many candidates also chose to discuss how the strength of the covalent bonds increased melting points rather than just considering the intermolecular forces. Answers were either very good or very poor. Where a candidate only scored two marks it was mainly due to not discussing the influence the number of electrons has on the strength of the force.

Q2(b) The best answers linked the type of bonding with the correct particles in just a few statements to score all four marks. Those candidates who attempted to fill the answer space often contradicted correct answers by discussing the intermolecular forces between the particles. Some very able candidates did not include that the particles in silicon are atoms whereas others gave answers which suggested that silicon was made up of molecules.

Q2(c) This question discriminated well between the most able, who found no difficulty writing and balancing the equation and the least able who frequently were not able to give the correct formula of the product, aluminium hydroxide. Those who managed to obtain the correct symbols often failed to provide the correct balancing number before the water.

Question 3

Q3(a) The vast majority of candidates were unable to describe the difference between a σ and a π bond. The simplest answer was that the π bond was the weaker bond or the σ bond was the stronger. Many candidates attempted to describe how the two different bonds were formed. It was clear that candidates understood the concept of the sideways overlap of the p orbitals to form the π bond but were unable to describe the formation of the σ bond. A common misconception was that the σ bond could only be formed by the overlapping of the s orbitals. The best candidates were able to articulate that the σ bond results from the head on overlap of orbitals resulting in the bond forming directly between two atoms whereas the π bond results in the electron density being located above and below the plane of the bonding atoms.

Q3(a)(ii) This question required candidates to apply their knowledge of *E/Z* isomerism to suggest why compound A did not have *E/Z* isomers. Whilst it was clear that many candidates understood the concept of *E/Z* isomerism many found it difficult to apply this concept and articulate an explanation.

Q3(a)(iii) Most candidates were able to draw the structural isomer of compound A and provide a suitable name.

Q3(b) Many candidates found it difficult to draw the structures for the two alcohols that could be dehydrated to produce compound A. This was surprising as it was a simple task to add water across the double bond of compound “A” resulting in two branched chained isomers. The most common incorrect answers were pentan-1-ol and pentan-2-ol, although some candidates shortened the chain length resulting in compounds containing only four carbon atoms.

Q3(c) The first of the six mark level of response questions required candidates to draw the mechanism of electrophilic addition, outline the two possible products and explain which one of these products would be the most likely to be formed. The most common mark for this question was five marks mainly due to candidates not being able to explain the formation of the major product in terms of the formation of the more stable tertiary carbocation in the intermediate stage of the mechanism. Candidate scoring five marks frequently quoted Markownikoff’s rule as an explanation. Varying degrees of competence was displayed in the production of the mechanism. The correct positioning of curly arrows was a skill that the most candidates had clearly mastered with many accurate mechanisms being submitted. Weaker candidates clearly need more time to develop these skills.

Question 4

Q4(a)(i) The poor quality of answers observed surprised the Examiners as this question had featured a number of times on legacy papers which would have been used in Centres to prepare candidates for this examination. Many candidates were not able to explain that bond breaking requires energy whereas bond making produces energy. For the reaction to be endothermic more energy is required to break bonds than is evolved when bonds are formed. In their answers candidates frequently stated that both processes required energy or that more bonds were broken than were formed.

Q4(a)(ii) Half of the candidates scored zero for this question, many failing to label the enthalpy change or to show this as an arrow pointing upwards. Although the question stated that the activation energy was not required, candidates frequently included it in their diagrams and then labelled it ΔH . Many Candidates did not write the formula of the reactants or products and those who did multiplied the species by two so as the diagram did not represent the enthalpy of formation.

Q4(b) This was a new addition to the OCR specification as part of the curriculum changes. The vast majority of candidates made a good attempt at this calculation which required both the rearrangement of a formula and the conversion of units of temperature and volume. The conversions and calculation did not prove that difficult for many candidates however answers were often not given to three significant figures or quoted in standard form resulting in the loss of one mark. Candidates clearly need to develop their mathematical skills in order to access the 20% of marks available for quantitative work.

Answer = 4.46×10^6 (Pa)

Q4(c) Many incorrect equations or correct symbol equations containing incorrect radicals were observed. A large proportion of candidates scored no marks on this question although the most able often provided both equations to gain two marks.

Question 5

Q5(a)(i) Candidates who failed to state that the gas being lost was CO_2 could not access the mark for this question. Vague answers relating to water being produced, products being gases, products being lost or a gas evolved were often given by Candidates.

Q5(a)(ii) The vast majority of candidates were able to complete this calculation arriving at the correct answer to score all three available marks. The most common error was in calculating the amount, in moles, of the SrCO_3 from the stoichiometry given in the equation. This resulted in an answer which was twice that expected however two marks could still be obtained by applying error carried forward.

Answer = 1.845 g or 1.85 g

Q5(b)(i) Very few candidates were able to explain the change in the rate of the reaction during the first 200 seconds of the experiment. This relatively straightforward question required a statement that the rate decreases as the concentration of the reactants decreases due to there being less frequent collisions. Although a large number of candidates were able to state that the rate decreases few were able to explain why. This was possibly due to candidates having to apply their understanding in an unfamiliar context rather than from a lack of knowledge

Q5b(ii) This was the first time AS level candidates have been required to calculate a rate of reaction from a graph and many found this quite testing. Although many knew that a tangent was required only the most able candidates were able to arrive at a value for the gradient that was within the expected range. Candidates sometimes took as their values the point at which their tangent cut the axes rather than calculating the change in mass or change in time.

Acceptable range 5×10^{-4} to 8×10^{-4}

Q5(c) This was the second question that required candidates to describe an experiment that they could have carried out as part of their course. Even if this experiment had not been completed in class, candidates should be able to recognise that mass needs to be measured over a period of time. As the reaction was between an acid and a carbonate a suitable named reaction vessel such as a beaker or flask was required. A balance was needed for mass measurement and a timing device to monitor time. A simple statement that mass should be recorded at a given time interval scored two marks with one mark being allocated to suitable apparatus. At this level it is expected that candidates will be familiar with the correct names for the apparatus required to carry out an investigation.

Question 6

Q6(a) The definition of a secondary alcohol was well known with most candidates being to express this to gain the mark available.

Q6(b) Although the weaker candidates appear to have little idea of the bond angles found in simple molecules many were able to pick up one or two marks for communicating that lone pairs repel more than bonding pairs. The more able candidates also described the number of lone pairs and bonding pairs and obtained the correct bond angle.

Q6(c)(i) The majority of candidates were able to identify the structure of the ketone formed in the oxidation of butan-2-ol but many were not able to construct a suitable equation. Water was often omitted from the equation on the right hand side whilst sometimes the equation was incorrectly balanced with a 2 being placed in front of the [O]. The most able candidates normally scored both marks.

Q6(c)(ii) Another question requiring candidates to evaluate a practical activity where responses were on the whole disappointing. Very few candidates were able to access both of the marks with the harder of the two marks being for suggesting why the apparatus was not suitable for the experiment. Clearly many candidates were able to suggest a better method of carrying out the experiment with reflux being often quoted.

Q6d Many good quality answers were given by candidates. Marks were sometimes dropped where answers were incorrectly rounded at the intermediate stage resulting in a percentage yield outside the acceptable range.

Answer 67.4%

Question 7

Q7 The final question on the paper was a six mark level of response question which required candidates to identify a molecule from a range of data. Most candidates were able to process the percentage composition data to arrive at an empirical formula but less able candidates then failed to use the data from the mass spectrum to arrive at the molecular formula. Candidates were generally able to use the infrared spectrum to identify the presence of -OH and C=O and could link this to the carboxyl functional group. The best candidates were able to identify the peak in the mass spectrum at 43 and to link this to a C_3H_7^+ fragment which led to the assumption that the carboxylic acid was butanoic acid. Many outstanding candidates were able to discuss the peak at 43 being that of a branched chain secondary carbocation and linked this to the correct branched product. Some answers were unstructured and disorganised and candidates should be encouraged when analysing data to organise their answer sequentially and discuss each piece of data in turn.

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