Results Summary

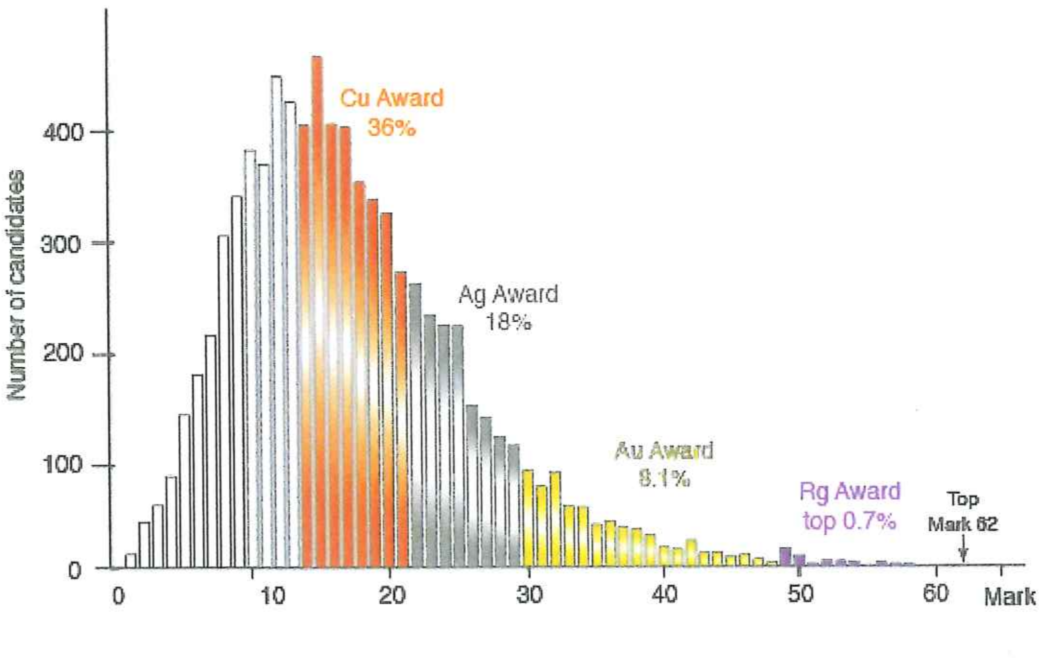
This year 547 schools submitted at least one mark and it is pleasing to see that at least one student from the majority of these schools received a certificate. The Copper certificate, reflecting a reasonable grasp of A-level material and the ability to apply this knowledge to novel problems, was awarded to 36 % of entrants. We felt a mark of 22 or above represented a very good achievement on this paper and showed the students were able to think their way successfully through unfamiliar material. Nearly a quarter of the candidates were of this standard and achieved at least a Silver Award. A mark over 30/65 was very impressive indeed and worthy of a Gold Award or higher; these students demonstrated their ability to tackle a range of different chemical topics under time pressure.

The Roentgenium Award was given to the top 0.7% of students. These students have been invited to attend a residential course at the University of Cambridge. The highest mark achieved this year was an outstanding 62/65. We were delighted to see three 'Year 11 or below' students achieve the Roentgenium award. It was very pleasing to see 39 schools from *all* sectors of secondary education represented in this group. Once again, it is clear that talented and ambitious students can be found everywhere.

We continue to encourage teachers to submit all marks scored by their students as a certificate at any level represents a significant achievement; any fears that this could ever count against a student in terms of university applications are entirely unfounded.

As the school details entered by the teachers automatically appear in the same format on the certificates, it is important that these are correct. Sadly we are not able to reprint certificates.

Award	Mark	Number of Students	Percentage
Roentgenium	49-65	54	0.68%
Gold	30-48	644	8.1%
Silver	22-29	1418	17.9%
Copper	14-21	2899	36.5%
No Award	0-13	2931	46.9%



Cambridge Chemistry Challenge Lower 6th

Thank you for participating in the 2018 Cambridge Chemistry Challenge for Lower Sixth (Year 12). Despite the inconvenience of GDPR, this year almost 8000 students participated in the challenge from around 540 schools. It was good see many new schools entering and winning certificates. It was also pleasing to hear that many schools now regard our competition as an integral part of the school calendar.

The feedback from schools was once again positive, with teachers saying they felt the paper accessible but challenging. The level of difficulty was comparable with the paper from last year resulting in similar grade boundaries. The highest scoring papers were moderated by the committee, with quite a number moving both up and down.

The paper, the mark-scheme, and the examiners' comments will appear on the website soon. We hope you feel that taking part in this competition was a worthwhile experience and we would welcome any additional feedback: please email feedback@C3L6.com.

For your interest a summary of the results is included over the page.

Supporters of C3L6

St Catharine's College Cambridge

UNIVERSITY of CAMBRIDGE Department of Chemistry

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The C3L6 committee

Claire Badger
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Peter Wothers

Feedback on questions

Question 1

Possibly inspired by the recent Arctic Monkeys' album that imagines life living in a hotel on the Moon, question 1 this year looked at the extraction of oxygen from metal oxides as a means to sustaining life in an alien environment. By structuring the question around some straightforward inorganic Chemistry, we tested key skills in the balancing of equations, the accurate and consistent application of oxidation numbers, and the understanding of units and their conversion. Additionally, the use of Hess' Law to determine the enthalpy of a reaction and the introduction of entropy provided a well-rounded assessment of problem-solving skills.

Part (a) was generally answered well with the most common error arising from candidates forgetting that 2 moles of SiO_2 were present in the mineral and that this had to be taken into account to find the correct percentage by mass. In addition to the mark-scheme, we allowed the combined masses of the two oxides in the mineral used (giving a single percentage answer) which was an occasional error.

Parts (b) (i), (ii) and (iii) were generally answered well, testing some fundamental skills that are covered in the first year of a pre-university course. Part (iv) provided a more significant challenge, yet the more common errors tended to arise from straightforward mistakes such as forgetting that O_2 is diatomic (so that the mass required division by 32, not 16). Other common errors were forgetting to use the stoichiometry of the equation, and multiplication of the resulting moles of titanium by the mass of titanium not the mass of the ilmenite.

Part (c) didn't appear to trouble the top candidates. It was very common to see carbon dioxide used as one of the gases making it extremely difficult to find the correct equation.

Part (d) (ii) required care with the reading of the question. The main error for candidates was forgetting to refer to the equation they had just written, instead using the equation above the table. Whilst entropy isn't typically covered in the first-year of their course, we hoped that students would use the description given to draw against their understanding of disorder. The best candidates correctly correlated the nature of a gas with greater disorder relative to liquids or solids. In part (iii) the better candidates remained untroubled by this standard Hess cycle question. As ever, drawing out the Hess cycle enabled a much greater clarity of answer as opposed to the attempted use of rote-learned equations. The use of significant figures was a common loss of marks with several students quoting their answer to 5 s.f. Again, despite the unfamiliarity of entropy in part (iv), students were not troubled by the use of it in a standard calculation so long as candidates considered the stoichiometry.

Recognition of the difference in units of enthalpy and entropy was the key skill tested in part (e). The main error involved candidates forgetting to divide the entropy by 1000. However, we observed that several candidates failed to link their answer to a qualitative description for the position of equilibrium.

Part (f) was a rather challenging question given the similarity in ionisation energies of magnesium and silicon. A common error was the assumption that magnesium is easier to ionise than aluminium. Most candidates correctly placed oxygen as the most difficult to ionise.

In part (g) (ii), the main error was forgetting to convert units of E_i from kJ mol^{-1} into J mol^{-1} for the equation to work. Failure to do this resulted in an answer of 99.9%. Of course, if 99.9% of the oxygen atoms were ionised, they could not be separated from the other ionised atoms!

Question 2

The inspiration for this question revolved around the growing use of sweeteners in commercial food and drink products, which is commonly referred to in the news. The interesting structures of these compounds, such as Sweetener D (Acesulfame-K), enabled the development of quite a stretching but accessible, organic synthesis whilst also allowing for some practise on carboxylic acids and their salts. The brilliantly titled paper *'Sweetened Swimming Pools and Hot Tubs'* provided some of the information for setting this question (Jmaiff Blackstock, L.K., Environ.Sci.Technol.Lett.,**4**,149-153).

(a) Whilst carboxylic acids are unlikely to have been covered in significant detail at this stage in the A-level course, we felt that sufficient information had been given to students to enable them to answer simple questions.

(b) The correct general formula should give an indication of the functional group present. However, we deemed it acceptable to use a molecular formula style answer, $C_nH_{2n}O_2$, and marks were therefore given for the correct molecular formula.

(c) We designed this to be an interesting take on the standard empirical formula calculation found in public exams at this level. The better students coped well with the slightly unfamiliar presentation.

(e) Here we allowed molecular formula representations of compounds, but candidates who replaced $2CH_3COOH$ with $C_4H_8O_4$ were penalised.

(f)(ii) Missing curly arrows was a common mistake which could have been avoided through more careful reading of the question. Again, incorrect reading of the question was the major flaw in the answers to part g), where the negative charge had to be drawn on an oxygen.

It was very surprising to see that a majority of candidates did not choose "nucleophile", with electrophile commonly being circled instead.

Parts (j) and (k)(i) were answered well, but it was a shame that many candidates omitted to circle any acidic protons on structure **H**.

Getting the final, correct structure of sweetener D was a challenging question designed to stretch applicants and very few students correctly answered this. The best candidates recognised that cyclisation through the oxygen to give a 6-membered ring was the only sensible answer. It was gratifying to see several students recognise this.

Part (l) did not trouble the top candidates but many came unstuck when thinking about the dilution factors that had to be taken into consideration: this was the most common loss of marks here.

(o) The most common mistake was not accounting for the sweetener D that would have been present in the city water supply. Candidates should have applied a baseline correction to the data. The answer that amused us most was the one that thought that there were in excess of 10 million litres of urine in the swimming pool – yuck!