2022 Chemistry Subject Assessment Advice

Overview

Subject assessment advice, based on the 2022 assessment cycle, gives an overview of how students performed in their school and external assessments in relation to the learning requirements, assessment design criteria, and performance standards set out in the relevant subject outline. They provide information and advice regarding the assessment types, the application of the performance standards in school and external assessments, and the quality of student performance.

Teachers should refer to the subject outline for specifications on content and learning requirements, and to the subject operational information for operational matters and key dates.

School Assessment

Assessment Type 1: Investigations Folio

The Investigations Folio contains at least two practical investigations and one investigation with a focus on science as a human endeavour.

Both assessment design criteria, Investigation, Analysis and Evaluation, and Knowledge and Application, are used for this assessment type. Student evidence in the Investigations Folio should focus on the science inquiry skills, explain connections with science as a human endeavour and apply science understandings. In at least one practical investigation, students deconstruct a problem and design a method to investigate one aspect of the problem. Students need to know the four key SHE concepts and understand what these concepts mean so that they can discuss scientific research in terms of these key concepts.

The more successful responses commonly:

* deconstructed open-ended problems that had several possible aspects to explore and allowed opportunities for individual design and investigation of an uncertain outcome
* provided a broad range of considerations for the deconstruction and design represented through concepts maps, lotus diagrams, and tables to deconstruct and arrange ideas
* included detailed evidence of explored procedures to clearly justify those that could be pursued or were not viable
* clearly separated the four pages of deconstruction and design from the report
* considered a range of possible variables, measurement techniques and equipment, and justified all selections made in relation to the student’s own design
* summarised variables to be controlled, and how and why they would be controlled
* considered relevant safety aspects including safe use and disposal of chemicals for the quantities and concentrations applied
* clearly identified relevant sources of error in an investigation and used their data to explain the effect of errors on the outcome and discuss the level of impact
* discussed a range of relevant sources of random and systematic that were often unique to the procedures undertaken and the data obtained
* presented data clearly in labelled tables and constructed graphs using appropriate conventions
* used the data obtained to identify and substantiate trends and conclusions
* justified conclusions and noted their limitations in terms of wider applicability
* clearly identified the SHE concepts that were the focus of the SHE investigation
* ensured that introductory chemistry supported the SHE concepts
* focussed on highlighting the links between science and society, rather than purely the chemical background
* chose a contemporary area of investigation for SHE that used a new piece of specific research or technology as the basis for discussion and enabled discussion of Stage 2 chemistry concepts that helped explain the research
* provided well substantiated opinions and justified conclusions
* referenced all sources of information using recognised conventions.

The less successful responses commonly:

* provided little evidence of individual deconstruction and design opportunities
* unpacked ideas in a deconstruction that were not explored through viable procedures or justified as a selection
* undertook designs with heavily set parameters leading to little evidence of individual thinking and unanticipated outcomes
* designed investigations with qualitative dependent variables, which often limited the quality of the analysis of data
* contained similar ideas and discussion points to reports from other members of their group/class due to excessive scaffolding on the task sheet
* used inappropriate graphs, to represent different types of data
* did not establish trends from or use the data obtained to formulate conclusions
* identified a limited number of generic errors that were nonspecific to the task and applicable to many investigations
* used terms such as precision, accuracy, reliability, and validity either incorrectly or without any meaningful discussion of these terms in relation to their data
* presented a report on a topic rather than an investigative exploration of contemporary aspects of SHE
* selected very general topics from the course that were not necessarily contemporary examples
* focussed too heavily on the background chemistry, leaving limited opportunity to explore SHE key concepts and connections
* addressed several SHE key concepts superficially rather one or two in depth
* utilised extensive text and paraphrasing from sources which did not link to SHE and was inconsistently acknowledged by referencing conventions

Operational Advice

If students present their responses in oral or multimodal form, 6 minutes is the equivalent of 1000 words. Students should not speed-up the recording of their videos excessively in an attempt to condense more content into the maximum time limit.

From 2023, if a video is flagged by moderators as impacted by speed, schools will be requested to provide a transcript and moderators will be advised to moderate based on the evidence in the transcript, only considering evidence up to the maximum word limit.

If the speed of the recording makes the speech incomprehensible, it affects the accuracy of transcriptions and it also impacts the ability of moderators to find evidence of student achievement against the performance standards.

Assessment Type 2: Skills and Applications Tasks

Both assessment design criteria, Investigation, Analysis and Evaluation, and Knowledge and Application, are used for this assessment type. Student evidence in the Skills and Applications Tasks (SATs) should focus on the science understandings, apply science inquiry skills, and explain connections with science as a human endeavour.

Teachers must ensure that questions in SATs are based upon content in the current subject outline.

The more successful responses commonly:

* included a variety of presentation formats and question types that enabled students to demonstrate varied skills
* used opportunities to present knowledge, understanding, application and analysis in tasks
* required the application of concepts beyond the contexts that were familiar or rehearsed
* required the construction of responses that drew from a range of topics and concepts and often demonstrated their interrelated nature
* linked evidence provided in a question to an appropriate SHE concepts

The less successful responses commonly:

* responded to questions requiring predominately recall of learned facts and demonstrated little application or analysis
* demonstrated poor use of chemical terms and conventions such as equations and structural formulae
* were hampered by the structure of tasks that did not allow students to provide evidence of deep understanding

External Assessment

Assessment Type 3: Examination

Examination questions are designed to assess students’ understanding and application of all three strands of the subject outline: the science understandings, the science inquiry skills and the key concepts of science as a human endeavour. All specific features of the assessment design criteria for this subject may be assessed in the examination.

As a general comment, poor and small handwriting did cost some students marks, as illegible responses are assessed as incorrect. Poor setting out of calculations, or showing no working during calculations, also cost some students marks, especially if they were unable to arrive at the correct answer. Teachers should encourage students to develop accurate habits in the use of units and correct number of significant figures in calculated answers. The latter was particularly poorly done this year.

Question 1

(a) (i) Generally well done, but sometimes poorly expressed. It should be straightforward to mention that both glucose and fructose are polyhydroxy due to multiple –OH groups in their structures, and that glucose contains an aldehyde group whilst fructose contains a ketone group. The most common mistake was not writing that there are more than one hydroxyl (alcohol, –OH) group in carbohydrates, whereas almost all students recalled that there is also an aldehyde or a ketone group. “Carbonyl group” was not awarded a mark here, as carboxylic acids, esters and other functional groups may also contain a ‘carbonyl group’. Students should be discouraged from naming ketone groups as carbonyl groups. The general formula Cx(H2O)y is NOT acceptable as a definition of a carbohydrate.

(ii) Poorly answered. Many students simply doubled C6H12O6 but then forgot to subtract H2O that is lost when two monosaccharides undergo a condensation reaction.

(iii) Well answered.

(iv) (1) Most students earned two marks as they could recognise and state that Tollens Reagent should be used because only the monosaccharide products of the hydrolysis contain an aldehyde group that would give a positive test (silver mirror). Very few went on to gain full marks by explaining that dichromate is unsuitable as it would oxidise the alcohol functional groups in all of the carbohydrates under consideration and thus would not be able to indicate whether or not the sucrose had been converted.

(iv) (2) Students frequently misinterpreted this question. The inactivity here refers to the enzyme not functioning in the medicine (when taken) NOT to sluggish activity when it is cold in the refrigerator. Students who hinged their responses on lack of kinetic energy were not awarded any marks.

Students who understood that the question referred to the enzyme’s inability to function, frequently lacked sufficient development of their response. Being stored for a time at too high a temperature or becoming contaminated with a substance that increased or decreased the pH of the medicine were acceptable suggestions for the condition that caused the inactivity. Successful responses included reference to the spatial arrangement of the enzyme having been altered (secondary bonding interactions disrupted) by this condition. As in previous years, simply stating that it had been ‘denatured’ was considered insufficient explanation.

(b) (i) Quite well done. However, a surprising number of students persist in incorrectly mentioning adsorption to a mobile phase. Adsorption is a term reserved for becoming ‘stuck’ on the surface of the solid, stationary phase. Another frequent example of poor use of language was "faster retention time" rather than "shorter retention time" as it travels faster with the mobile phase.

(ii) Well answered.

(iii) Generally well answered, although many students did not recognise that ppm and mg per L are the same unit. They should have divided the 36.4mg by 0.375L (correctly converted from 375mL) to get ppm and then compared the answer with the Australian standard. Very few did not earn the final mark by writing this concluding statement related appropriately to their calculated value.

(c) (i) This equation was poorly completed, if attempted at all. Many students did not correctly recall the formula of sodium hydrogen carbonate and still more were unable to draw the correct structure of the carboxylate anion or salt product. Some candidates used unnecessary coefficients to balance the equation. Such general reaction patterns for acids should be learned at Stage 1 and reviewed at Stage 2.

(ii) Well answered, with most students recognising that the salt (ionic) form has increased solubility in water.

(iii) (1) The most common mark scored for this calculation was two of the possible four. Most students failed to recognise that one piece of data used in the calculation had only two significant figures and thus the final answer should be expressed to only two significant figures. (Lack of appreciation of appropriateness of number of significant figures to which data is given remains a significant problem in practical reports also).

Students should be encouraged to check that they have used all given data when calculating a final quantity. Many lost marks for not reversing the dilution factor as a final step in their calculations.

(iii) (2) Multiplying their answer from part (1) by molar mass and dividing by 10 were the two steps necessary here and most students knew these steps quite well. Students are to be encouraged to ‘invent’ a number to manipulate if they were unable to complete part (1). Errors that were carried forward were not penalised.

Question 2

(a) Most candidates correctly identified chlorine and bromine as being able to act as oxidisers (oxidising agents) here. Less successful candidates gave “high electronegativity” as the property, which is not the same thing (e.g. permanganate is a strong oxidiser with anti-bacterial properties but does not have high electronegativity). Some students mentioned unrelated properties such as the ability to form –1 ions.

(b) (i) Most responses were correct. Students should have seen bromine solution, which is orange in colour (or yellow when more dilute). Some students stated a colour change and were penalised for not answering the question.

(ii) A significant number of students stated that increased pH meant increased H+ ion concentration, but the reverse is true. Most were then able to correctly argue, using Le Chatelier’s Principle, a shift towards the appropriate side of the reaction in order to partially counteract the change, resulting in a corresponding decrease in concentration of bromine and hence less intense colour

(c) (i) Generally, well answered. Some students did not use pOH = 14 – pH as a first step and hence antilogged -8.4 instead of -5.6. Some students omitted the power of ten when writing in standard form.

(ii) This question was poorly answered. Successful candidates were able to use “pH of solution” as the independent variable, correctly identifying its effect on percentage ionisation of the two acids. Unsuccessful candidates could not read the graph in this way.

The most successful candidates chose a point of comparison such as the pH at which the acids first measurably ionised, or the pH at which they each reached ‘100%’ ionisation. They then made comment on the fact that a higher pH was required to ionise HOBr to the same extent as HOCl and then concluded that HOBr must therefore be the weaker acid, since weak acids ionise less well in solution.

Markers noted with concern that a large number of students referred to the RATE at which the acids ionised, but there is no time or rate data provided.

Question 3

(a) Very poorly answered. Whilst many students were able to identify that C18H38 has a longer carbon (hydrocarbon) chain than C14H30, many were unable to explain how this affects combustion products. Successful students gave one of two acceptable explanations – that the larger molecular size increases the secondary forces between the molecules, making C18H38 more difficult to vapourize and mix with air, resulting in less complete combustion and more soot produced OR that a higher oxygen to fuel ratio is required for complete combustion of C18H38 and hence under the same conditions C18H38 is more likely to produce soot.

Less successful students simply stated that “more oxygen” would be required for complete combustion of C18H38, or that it would “take longer” to completely burn, failing to recognise that both fuels would be exposed to the same concentration of oxygen and for the same amount of time in the combustion chamber.

(b) Also poorly answered. Many students ignored that the question asked them to compare the COMBUSTION of biodiesel compared with that of diesel from fossil fuels. Successful candidates recognised that the combustion of BOTH produce carbon dioxide, possibly in similar proportion. They then went on to explain that biodiesel is sourced from recently growing plants which absorb carbon dioxide as they photosynthesise, so that the net addition of carbon dioxide to the atmosphere by combustion of biodiesel fuels is much, much lower than that of fossil fuels in which the carbon has been stored for millions of years.

Less successful candidates tried to include points about the mining or harvesting of the fuels, the transport of the fuels, and even tried to relate this response to part (a), leading to the inclusion of much writing that was, at best, irrelevant. This question part was certainly not about complete and incomplete combustion.

(c) (i) Poorly answered. Students did not seem to be able to apply knowledge that biodiesel molecules are typically methyl or ethyl esters of a fatty acid. Since the fatty acid formula was provided, successful candidates simply replaced the H of the carboxyl group with a methyl or ethyl group.

(ii) Generally done well with most students being able to correctly construct an equation for the complete combustion of a carbon-based fuel. The most common mistake was incorrect balancing of the equation.

(d) Many students were unable to perform this calculation. Poor setting out hampered the awarding of any marks for process in many cases. Students did not recognise that multiplying a fuel’s energy density (in MJ kg–1) by its density (in kg L–1) gives energy capacity in MJ L–1. Performing this step for diesel, and multiplying by 60L, then gives the energy (in MJ) to be divided by biodiesel’s energy capacity in MJ L–1 to reach the final answer of 69L.

(e) (i) Reasonably well answered. The expected equation was 2NO + 2CON2 + 2CO2 but the correctly balanced equation for nitric oxide being decomposed to nitrogen and oxygen gases was also accepted.

A surprising number of students incorrectly had nitrogen oxides being formed in the products.

(ii) Well answered. Students must be careful, however, to address the question as it is written. For example, there was no requirement here to show how a nitrogen oxide was formed in the engine in the first place.

Communication is the key here – explanations need to be written as well as providing at least one relevant equation that is referred to in the answer. Some students lost marks for not elaborating on the undesirable consequences of having nitrogen oxides, and the ozone that results from their photochemical reactions, present in the troposphere. Many students seem to be under the misapprehension that nitrogen oxides are significant greenhouse gases in our atmosphere.

(iii) Many students missed the focus of this question — the nanoparticle size of the catalyst NOT the presence of the catalyst itself. One advantage of this is certainly the increased total surface area of the same mass of platinum, leading to an increased rate of catalytic conversion; another advantage, less frequently stated by students, is that a lesser mass of platinum is required for the same rate of catalytic conversion if used in the nanoparticle form, which means that the cost is kept down as platinum is expensive, or that our precious platinum resources can be used more sparingly and conserved.

(f) Very well-known and answered. Most students scored three of the possible four marks allocated. The most common omissions were to neglect that the greatest oxygen depletion in the waterway is caused by the decomposition of dead organisms, or to neglect to conclude with a further detrimental effect of this oxygen depletion.

(g) Not well answered. Many students seemed not to know this part of the nitrogen cycle well. Nitrogen fixation by bacteria living on the roots of leguminous plants converts nitrogen from air (not able to be used by the plant) to ammonia/ammonium ions which are water-soluble and can be taken up from the soil water by the roots of plants. (Some students even went on to correctly mention that nitrifying bacteria in the soil may convert the ammonia to nitrites/nitrates which are also water-soluble and can be up-taken by the plant, but this response was not required.)

Question 4

(a) (i) A surprising number of candidates did not gain two marks for this question.

Many gained one mark for the correct configuration of a bromine atom (ends with 4p5), but did not add an electron for the bromide ion (4p6). Some were awarded no marks as they had subtracted one electron (4p4). Still others lost a mark for use of incorrect notation.

(ii) Most commonly candidates gained one mark for starting the line at a higher point (*y*-axis), but missed the second mark due to not showing a steeper slope. A mark was deducted if the new line crossed the original line. Those who scored no mark at all failed to interpret the question correctly.

(b) (i) Many candidates did not show an understanding of electrolytic cells, claiming formation of bromine at the cathode or not including mention of electron loss or oxidation. Many candidates mistakenly identified the species being oxidised as “bromine” or “bromine ions” rather than bromide ions.

In very few responses did students successfully provide a balanced half-equation showing the loss of electrons by bromide ions (not a compulsory feature).

(ii) Although this was generally well answered, many students incorrectly claimed that magnesium ions were formed at the other electrode. There were a few strange answers such as water, chlorine, magnesium bromide, indicating guessing rather than understanding of electrolysis.

(iii) Well answered with the majority of candidates being awarded two marks for claiming reduced costs due to less energy/electricity requirements to keep compounds molten by heating.

(c) (i) It was pleasing to see the majority correctly stating ‘greater’ or ‘greater than zero’. Some expressed this as ‘positive’, which was also accepted.

(ii) Some students did not understand the ICE concept and were unable to calculate the equilibrium mole values. Many students did not convert moles to concentration by dividing by the volume of 5 litres. It was pleasing to see a significant number of candidates successful in writing a Kc expression.

(iii) Generally candidates answered this quite well.

[It should be pointed out that the system cannot actually counteract an imposed temperature change, as in practicality/industrially the temperature will be held constant at the new level. The equilibrium does shift in the endothermic direction if the temperature is increased, however, and the K value cannot therefore remain the same value.]

(d) SHE — many students were able to make reference to the SHE concept and identified two points of benefit from the text, but did not support these through elaboration. Better responses elaborated on the benefit of ‘communication and collaboration’ through sharing expertise and data, saving time, arriving at a solution at a faster rate and learning from past experiences.

It was common for candidates to write a statement about how the reduction of the greenhouse gases will lead to climate change or global warming, but this lacked the elaboration required. Successful responses were also specific to the benefit to society — many claiming the reduction of a greenhouse gas would decrease the number of severe/extreme weather events or rising sea levels caused by global warming.

Question 5

(a) (i) It was pleasing to see this generally answered well, gaining two marks.

Candidates who lost a mark commonly either omitted electrons altogether, or had them on the incorrect side of the half-equation. Incorrect balancing resulted in another mark penalty. It was evident that many candidates were unable to infer that oxygen from the air was used in this equation.

(ii) Generally well answered with most interpreting the graph correctly and stating that the activation energy is lower with a platinum catalyst. It was common for candidates to also state that catalysts provide an alternative pathway for the reaction to proceed (with lower activation energy).

The most successful responses then pointed out that a higher number of particles are then able to collide with activation energy (or with energy that exceeds the activation energy) to form products, hence increasing the reaction rate. Rote-learnt explanations did not always refer to the diagram (which was specifically required by the question).

(b) (i) Candidates generally answered this well with the most successful responses including (increased) strength/rigidity/durability.

Unsuccessful responses stated bonding ideas without relating this to the desired improvement in physical property (the bonds within the structure are strong/covalent bonds/ crosslinks); as a stand alone response these did not gain a mark.

(ii) Generally well answered with the majority of candidates able to obtain two marks for mainly claiming the renewable and non-renewable sources for carbon fibre.

The more successful responses stated that using rayon would conserve petroleum/fossil fuels as they are a finite resource, that could be otherwise used elsewhere than for carbon fibre, (i.e. pharmaceuticals).

Some students used terms such as “sustainable” or “environmentally friendly” without senior chemistry level elaboration.

Since the carbon fibres are not being burned, reference to the enhanced greenhouse effect was irrelevant/inappropriate.

Two common misconceptions seemed to be that petroleum of itself is a contributor to greenhouse emissions and that rayon made from trees would make the carbon fibre biodegradable as it was derived from a natural product.

(iii) (1) Frequently answered very well and candidates were able to successfully state condensation.

(2) It was pleasing to see this answered well, with the majority of successful responses presented in skeletal form.

One common error was missing hydrogen atom(s) from the carbon chain for those that didn’t draw skeletal form. Another common error was students drawing amide groups instead of amine groups.

(3) The majority of students answered this successfully.

Some gained only one mark by missing one or both numbers; 1, 4 or di. Another error was incorrectly naming the alkane chain.

Although not penalised, punctuation notation use in nomenclature was frequently incorrect.

(iv) The majority of candidates successfully were able to state ketone.

The general term for a C=O bond, carbonyl, should not be used in place of the correct functional group name (as it is present in several different functional groups) and alone was not awarded the mark. Unsuccessful responses included carboxyl or ester.

(v) Poorly answered. Unsuccessful candidates seemed not to understand the difference between a composite material and a thermoset polymer. Less successful responses frequently made no reference to physical properties, or stated that the blended materials are difficult to separate but gave no explanation for this. A further incorrect response was to claim that the different melting points of the blended materials is what makes composites hard to recycle.

Question 6

(a) Successful candidates recognised the esterification of some of the carboxyl groups along the chain and hence were able to identify compound Y as *methanol*. Incorrect responses included *alcohol*, *methane*, *ethanol* or *water*.

(b) (i) Generally well answered. Successful candidates correctly used the dotted/broken line convention to represent the secondary interaction between the H of one hydroxyl group and O of a nearby hydroxyl group in the second chain. Successful candidates also correctly used delta notation to show causal hydroxyl group polarity. Mainly two or zero marks. Less common responses successfully completed a hydrogen bond between ester and hydroxyl groups.

Unsuccessful candidates showed hydrogen bonding involving a non-polar hydrogen (e.g. from the hydrocarbon ring), or used incorrect notation.

(ii) (1) Well answered.

(2) A surprisingly large number of candidates were unable to identify the interaction shown between chains as *ionic*. One common incorrect response was ion-dipole bonding.

Students should know that the term “ion-ion bonding”, whilst descriptive, is not conventional.

(3) Well answered.

(c) (i) (1) Well answered.

(2) Poorly attempted.

Many unsuccessful responses referred to an extension of the calibration line/extrapolation to include a 0.72 absorbance. This is not appropriate as we are not shown that the linear relationship holds true at higher concentrations. Others simply explained how a spectrometer works.

More successful responses involved construction of a new calibration plot, using standard solutions of higher concentrations, prior to the determination. The most successful responses suggested accurate dilution of the solution by a known factor (such as 2) so that its absorbance would now fall into the range of the calibration curve.

(3) Very few candidates attained the maximum mark here as most referred to a unique/specific wavelength being required to excite the calcium atom or ion, but did not refer to electrons or the electronic configuration.

(ii) (1) Less than half of all candidates attained this mark. Many did not include the 2– charge.

This question proved to be one of many that a substantial number of candidates did not read sufficiently closely; they did not include the formula in the answer, recording only the charge of the ion.

(2) Generally well answered. Successful candidates usually provided an equilibrium-based response (an increase in calcium ions (aq) would disturb the equilibrium to shift towards more calcium ions binding to the zeolite). Many of the successful candidates also provided a correct reversible reaction equation to assist their explanation.

Less successful responses mentioned cation exchange but made no reference to aluminosilicate as having a negatively charged surface OR simply stated that calcium attracted to aluminosilicate without explaining why sodium ions were removed.

(iii) (1) Biodegradability was poorly understood by many candidates. Unsuccessful responses claimed that polyethene is biodegradable due to weak dispersion forces with a reference to low melting points.

Partially successful candidates stated that it is not biodegradable but could not explain.

More successful responses explained that it lacks the reactive sites for microbes/enzymes to break down/hydrolyse.

(2) Many students incorrectly claimed that these plastic bags won’t go to landfill. Better responses mentioned a reduced time in or reduced accumulation of landfill OR mentioned a reason why it may be beneficial to breakdown earlier in reference to marine life.