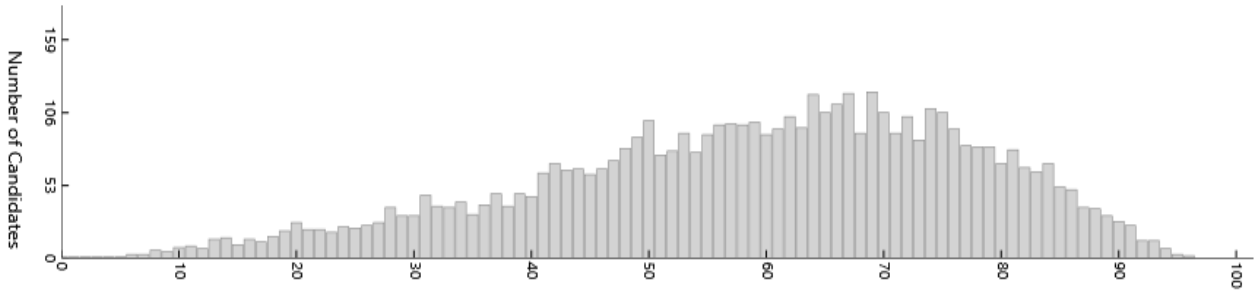
Government of **Western Australia**
School Curriculum and Standards Authority

Summary report of the 2016 ATAR course examination: Chemistry

Year	Number who sat	Number of absentees
2016	4997	57

Examination score distribution



Summary

The 2016 examination paper was attempted by 4997 candidates, slightly less than the 5195 candidates in 2015 but maintaining a level above the pre 'half-cohort bubble' of 2014. Chemistry still appears to one of the most popular of the science, technology, engineering and mathematics (STEM) courses.

The paper as a whole was well received with most candidates managing to attempt the majority of questions. Feedback from examination markers and teachers indicate that the questions reflected a wide range and good spread of the syllabus and that the candidates seemed to have sufficient time to finish the paper. The examination stayed within the boundaries of the syllabus, was considered fair, without surprises and was clear so candidates understood what was being asked. One criticism of the paper was that it did not offer enough challenging questions, requiring higher order thinking or linked concepts and principles from different areas of the syllabus, which would discriminate the very top candidates.

The statistical reports generally support these perceptions. However, the examination mean was 58.73% and the standard deviation was 18.47%. The paper functioned well to discriminate between the ability of candidates with scores ranging from 0.00% to 96.16%.

Section means were:

Section One: Multiple-choice	Mean 16.68(/25)	Max 25.00	Min 0.00
Section Two: Short answer	Mean 19.76(/35)	Max 33.10	Min 0.00
Section Three: Extended answer	Mean 22.39(/40)	Max 39.53	Min 0.00

The mean of 58.73% is an increase on the 2015 paper which had a mean of 55.99%. The mean of section one was 66.72%, up 1.88% from 2015; the mean of section two was 56.46%, up 2.91% and the mean for section three was 55.98%, up 3.35%.

Being the first examination for the new ATAR course, it served to provide a very accessible assessment of the new syllabus material. Many questions were deliberately written in the language of the new syllabus.

General comments

Generally, candidates demonstrated familiarity with most of the concepts and principles of the course but were unable to provide comprehensive explanations, drawing on and linking fundamental chemical principles. Candidates need to realise that marks are not awarded for re-stating information provided in the questions nor for vague references. It was evident within the examination that candidates could often do the calculations well but many did not express themselves clearly and concisely using the appropriate scientific terminology when providing justifications or explaining concepts.

Some markers felt that it was a reasonably difficult paper, especially for the weaker candidates. However, others commented that it was on the easier side with the calculations being very straightforward except for question 42 parts (f) and (g). The perception was that there were only a few questions which could discriminate the top candidates, notably questions 32(b), 34(b), 37 and 39(d).

It was suggested that about 20% of the paper were effectively recall questions rather than applying knowledge. For example, question 26 and question 40(b) combined to give 16 marks on redox chemistry and question 28(b) on an industrial process.

A perception expressed was that the examination paper was very heavily weighted towards organic chemistry. This is probably true as nearly half of the syllabus is specifically organic chemistry or uses organic chemistry as the context in which chemical principles are presented.

It is often problematic in allocating appropriate marks to the different concepts and skills being assessed in examination. This is illustrated by comparing question 31(b) with question 33(b). Question 33(b) was allocated three marks for, what on first appearance is the one concept repeated three times (the successive ionisation of the acidic hydrogen on a carboxylic acid group) yet in order to earn the full three marks candidates needed to:

- recognise, relate and draw corresponding structures
- identify the (–OH group) as being unreactive
- determine that the three (-COOH groups) each in turn lost a proton (H^+) and gained a negative charge.

On the other hand, question 31(b) was also allocated three marks and required three separate and significant chemical concepts.

Candidates did not answer question 35 and question 37 on intermolecular forces well. The syllabus states: '*organic compounds display characteristic physical properties, including boiling point and solubility in water and organic solvents; these properties can be explained in terms of intermolecular forces (dispersion forces, dipole-dipole interactions and hydrogen bonds) which are influenced by the nature of the functional groups'.* This has historically been an area of weakness and remains so. Candidates often fail to recognise that molecules might exhibit more than one type on intermolecular force and that given a large enough molecule, the cumulative dispersions forces are often greater than the other forces present.

Many candidates were not allocated full marks for their answers involving calculations because their setting out was untidy and lacked clarity; many candidates, missed critical steps and failed to identify clearly to which species they were referring which resulted in ambiguity. If a mistake was made resulting in an incorrect answer and the mistake cannot be identified, candidates scored lower generally than they otherwise would have done. Full marks cannot be awarded to an answer if it is not shown clearly how that answer was derived.

Often there was a lack of clarity of logic in the steps undertaken to solve a problem, justify a response or explain an answer. The lack of appropriate units being used throughout working and especially for a final answer added to this problem.

As indicated in the examination design brief, the new syllabus demands an understanding of error in determining a quantifiable answer and answers are now expected to be expressed to the appropriate number of significant figures. While all answers should be so expressed, there was only one question in this examination paper where marks were specifically allocated for the appropriate number of significant figures; some candidates did not express the final answer to the appropriate significant figure and so were not awarded this mark.

Another area of concern is the tendency for candidates to use minimal scientific jargon and expression leaving the marker unable to determine whether the candidate did not know or did not take the time to express what they did know.

For example:

(i) in question 34, many candidates failed to demonstrate how they arrived at the reading off the curve and simple stated a figure to one significant figure. Candidates need to demonstrate:
    - care when reading off the graph in an examination, they need to demonstrate they have used a ruler by showing the relevant markings on the graph rather than just 'eyeball it'
    - an appreciation for the degrees of accuracy available when reading an equivalence point; stating '5.0' or '4.8' rather than '5'.

(ii) many candidates used lazy expressions simply referring to the ambiguous 'NaOH' rather than 'sodium hydroxide solution' or 'NaOH(aq)'. Strictly speaking, NaOH refers to the compound which is a solid at normal temperature and pressure.

(iii) many candidates failed to indicate the conditions (catalyst/acidic conditions) for reactions when writing the equations depicting particular processes.

An area that distinguished candidates of different abilities was their understanding of the:

- process involved in the buffering action in a buffering system
- inter and intra-molecular forces attraction causing B-pleating.

As has always been the case, the examination markers seek to award all the marks possible to the candidate but this is not possible if the candidates' responses cannot be read because their writing is illegible or the pens or pencils used are too light. If the candidates' work cannot be read, they will potentially miss out on marks.

Advice for candidates

- Be aware that the examinable content of the syllabus includes knowledge, understandings and skills.
- Be conversant with the terms used in the syllabus, e.g. chemical test, data, evidence, genre, hydrolysis, hypothesis, ionisation energy, law, measurement error, origin of intermolecular interactions, partial pressures, polarities, polymerisation, pyramidal, risk assessments, research ethics, significant figures, systematic error, theory, trend, uncertainty etc.
- Understand the differences between similar terms: e.g.
    - intermolecular force and intramolecular force
    - equivalence point and end point.
- Practise writing clear, concise and coherent explanations and justifications; incorporating illustrative, labelled diagrams that are clear and relevant.
- Make it a habit to use the appropriate units and express numerical answers to the appropriate significant figures.

- Be familiar with the content of, and how to use, the Chemistry Data Booklet; knowing where to find the information it contains quickly.
- Know how to generate, read and apply data from graphs and tables.
- Use the given formula to determine the nature and bonding of a substance and all its intermolecular forces.
- Be familiar with, and how to clearly express, the expected observations and inferences that can be made for the reactions indicated in the syllabus. For example: All solutions are clear; some are colourless and some exhibit a colour. Referring to clear solution is redundant and is not the same as referring to a colourless solution. Copper sulfate solution is blue, while sodium sulfate solution is colourless; both are clear because they are solutions.
- Practise writing equations providing the appropriate formula and state symbols for only those species that are taking part in the reaction unless otherwise directed.
- Answer questions with specific reference to what the question demands rather than in general terms or by implication. Candidates are not necessarily awarded any marks for correct chemistry unless it pertains specifically to the question asked.
- Read and select the relevant information provided carefully in order to answer the specific question asked.
- Be prepared for the examination with all the authorised writing materials you might need, choosing pens and pencils which are easy to use and to read; have spares.

Advice for teachers

- Ensure coverage of all syllabus dot points as set out in the syllabus document. The entire syllabus is not necessarily examined in any one examination but could be expected to be assessed in its entirety over the course of a few years. Some syllabus points are examined regularly as they are essential for the understanding and communication of chemical concepts and processes.
- Keep the Learning Outcomes clearly in mind, the knowledge, understandings and skills examinable are found in the Unit Content. This includes:
    - Science Inquiry Skills
    - Science as a Human Endeavour
    - Science Understanding
- Note that Le Châtelier's Principle is a predicting tool not an explanation. Distinguish between the use of:
    - collision theory to explain the changes in rates of reaction
    - the change in rates of the forward and reverse reactions to determine and explain the effect on equilibrium position
    - Le Châtelier's Principle to predict the impact of changing conditions to a system on its chemical equilibrium.
- Engage students in conducting relevant experiments and problem solving. This year, candidates struggled to apply knowledge of common laboratory procedures.
- Insist that students use the appropriate units and express numerical answers to the appropriate significant figures unless otherwise directed.
- Provide students with practice in writing extended answers, justifications and explanations; incorporating illustrative diagrams that are clear, labelled and relevant.
- Encourage students to set out their working and reasoning clearly; full marks are not awarded unless it is clear how the answer was obtained and the relevant chemical ideas (such as relevant mole ratios) are shown.

Comments on specific sections and questions

Section One: Multiple-choice
Attempted by 4997 candidates Mean 16.68(/25) Max 25.00 Min 0.00

The easiest questions, with means of 94% and 86% respectively were questions 23 and 19.
- Question 23 required candidates to recognise the process of fermentation from a flow chart provided.
- Question 19 required candidates to recognise the products of simple organic reactions.

Another seven questions had means of 80% and above; these included questions 1, 8, 15 and 16. Most of the more capable candidates did well with these questions.
- There was some criticism of question 1 as the addition of an inert gas in a closed system required that constant volume or constant pressure also be stated. This did not seem to have negatively impacted candidates' capacity to answer this question correctly.

The most challenging questions, with means less than 50%, were questions 3, 6, 20 and 22.
- Question 3 required candidates to select the correct statement concerning a given equilibrium system.
- Question 6 required candidates to identify the set of data that indicated a systematic error; this aspect of experimental error is new to the Chemistry syllabus.
- Question 20 required candidates to identify the compounds that produce a polymer. The alternative given as the correct answer included four compounds, including compound III (CH_2=CHOH). This compound has the ability to slowly tautomerise to the aldehyde (CH_3CH=O) and in that state could not be used to produce a polymer. At room temperature, acetaldehyde (CH_3CH=O) is more stable than the vinyl alcohol (CH_2=CHOH). The tautomerisation occurs slowly normally but is catalyzed by acids. Photo-induced keto-enol tautomerisation is also viable under atmospheric conditions. Candidates were unlikely to know this and hence answer (c) was chosen as the correct answer. Many candidates chose answer (a) which does not include structure III.
- Question 22 required candidates to recognise the relative hardness of water samples according to the volume of soap required to produce a permanent lather. The distractors of boiling point and mass of a precipitate produced caused confusion for candidates; making them very effective distractors.

Section Two: Short answer
Attempted by 4990 candidates Mean 19.76(/35) Max 33.10 Min 0.00

Section Three: Extended answer
Attempted by 4982 candidates Mean 22.39(/40) Max 39.53 Min 0.00