2024 Stage 6 Consultation – Chemistry: Science Teachers' Association of NSW Response
https://www.nsw.gov.au/education-and-training/nesa/news/syllabus-consultations

1. What are the strengths of the draft syllabuses?	**Structure (overall course)** ○ Refinement of four modules to three in year 11 is supported. **Structure (of curriculum points)** ○ There is increased clarity in some places about what is expected – thank you! The note about simple organic compounds referring only to the substances specifically addressed will help with consistency of teaching expectations and preparations for the HSC exam. ○ Less content in each dot point - dense dot points have been split into multiple points. This will make planning and reading easier. We appreciate this but have also noted below a few further curriculum points that would benefit from being divided. ○ The removal of sub-dot points is helpful for clarity. ○ The removal of 'including but not limited to' is strongly supported; this will be helpful for clarity in exam preparation, new teachers and exam writers. ○ The identification of dot points where secondary-source investigations are appropriate is in some ways supported; secondary-source investigations are an important skill for Stage 6 students. ○ We are interested in discussing why we have mandated which dot points need to be subject to a secondary-source investigation rather than suggesting places where this might be appropriate, and allowing the teacher to choose the best place for this? For example, why does the secondary-source investigation need to be about Tc-99m rather than F-18 or Am-241? You could allow teachers or students to choose a radioisotope that is aligned in some way with one of their interests. ○ The content is very explicit, and ambiguity has been removed.

	Working Scientifically
	
	• “Use evidence and correct scientific language and terminology to address a specific audience and purpose“
	  o Address specific audience and purpose is good practice for science communication.
	• “Explain why current scientific knowledge is both contestable and testable by further inquiry”
	  o Strongly supported, students need to understand science is ever changing and evolving with new evidence rather than “the truth”.
	• “Assess the reliability of primary and secondary data from a range of sources”
	  o Strongly supported, this is an extremely important skill, particularly at this time, and it is important that students learn this at school before needing to make decisions without support in a university environment.
	• “Assess the validity, reliability, accuracy and precision of data and information”
	  o Addition of precision supported.
	  o Stronger emphasis on evidence-based arguments and conclusions supported.
	
	Content Changes - General
	
	  o Inclusions of scientists in particular female scientists is supported.
	  o Removal of separating mixtures, amines and amides and organic bases.
	  o Practical's very prescriptive with intended aim.

2. Are there any content points requiring further refinement?	**Properties and Structure of Matter** **Separation of mixtures** • “Discuss traditional Aboriginal methods of separating mixtures by using woven baskets for filtration and extracting dyes from plants” o Plural – methods – there will need to be support here. • “Use the particle theory to explain how homogeneous and heterogeneous mixtures are separated” • “Plan and conduct a controlled laboratory experiment to accurately determine the percentage composition by weight of a mixture”

	- These introductory outcomes need to change. If the students are given a strong context in terms of separation methods and mixtures, they will be able to link in the Aboriginal methods in a more rigorous manner. - <u>Suggestion</u>: Move the Aboriginal methods to third outcome - Also add specific techniques conducted in prac work that mirror ATSI methods need to be explicit here. - Specifying the types of separation techniques students should know about would add to clarity here. Examples below. Is the syllabus intending that students know all or some of them? – Filtration – Sedimentation & Decantation – Evaporation & Crystallisation – Magnetic separation – Separation funnels – Fractional Distillation – Chromatographic techniques **Atomic structure and electron configuration** “Use the periodic table to construct representations of atoms in terms of the particles present, and in terms of the element symbol, atomic number and mass number” - Model the sub-atomic particles of elements using the periodic table. - Construct models of atoms to demonstrate discrete energy levels and electron configuration” - What kinds of models are we imaging here? It might be helpful to specify the model of the atom students should be able to understand for clarity - With spdf notation, is this just spdf with superscript or arrows in boxes? Should students understand rules about placement in suborbitals? - Addition of nuclear chemistry concepts supported although wonder if they should be under their own heading? “Conduct a secondary-source investigation to collect, tabulate and plot data on atomic radii, ionic radii, first ionisation energy and electronegativity of elements” “Interpret data to explain the trends in atomic and ionic radii, first ionisation energy and electronegativity of elements “

	○ Dot points on periodic trends encourage less rote learning of trends, rather students understanding them, this is supported
	
	Patterns and trends in the periodic table
	• "Describe Aboriginal perspectives on the nature of matter that show observations of properties of substances (Aboriginal Dreaming stories, Torres Strait Islander myths and legends)"
	  ○ Not sure how this is going to relate strongly with properties of matter – either a direct comparison or contrast is needed.
	  ○ We need info with the specific stories and country the stories have come from.
	  ○ ATSI perspectives provide a holistic view of matter – this dotpoint does not belong here where the rules of organisation fit with the understanding of how to use the PT to find information.
	
	Chemical bonding
	○ Structurally this unit needs to be updated. To support teachers, it's recommended this whole section is restructured. Think about the different types of bonding then teach into this.
	
	• "Use models to demonstrate the features of metallic bonding"
	• "Explain metallic bonding in terms of electrostatic attraction"
	• "Analyse the relationship between metallic bonding and the melting point, boiling point and electrical conductivity of metallic elements"
	  ○ Recommend flipping these outcomes so that modelling comes last, unless we are doing discovery learning? In this case, we need to factor in time to re-teach if they have focused their modelling on inaccurate information.
	
	  ○ There is not enough clarity yet around where we are teaching metallic, ionic bonding in a nano sense (between individual atoms) only or whether teachers need to cover metallic, ionic lattices. It is explicitly specified that discrete covalent compounds and giant covalent structures are covered, so why not for ionic and metallic compounds? [although ionic and metallic substances only exist in lattice form, historically textbooks have taught these bonds in the isolated, between individual atoms, sense]

	• "Conduct a practical investigation to process data and explain the trends in melting points within and between group 1 and group 2 chlorides "
	  ○ How are you envisioning this is completed in a high school classroom? The melting points of these compounds are extremely high and normally measured using specialised equipment. Is the intention that 'practical investigation' just means to process the data and explain the trends? If so, this is unclear, refer to other comments about clarity around the meaning of practical investigation
	
	• "Predict the molecular geometry and polarity of covalent bonds using electron dot structures, valence shell electron pair repulsion (VSEPR) theory and electronegativity"
	  ○ Does this make sense? Should this say polarity of "covalent molecules", not "bonds"? Polarity of covalent bonds is determined by electronegativity?
	
	• "Relate the features of dispersion, dipole–dipole and H-bonding to intermolecular forces"
	  ○ Does this point make sense? Should this say describe the features of each?
	
	• "Evaluate how models are used to illustrate the key characteristics of metallic, ionic and covalent compounds, and relate them to compounds' physical properties"
	  ○ Love the first part of this, not sure what is added by 'relate them to the compounds physical properties'.
	
	Quantitative chemistry
	
	Conservation of mass
	
	  ○ <u>Suggestion:</u> Start with an outcome relating to teaching the law of conservation of mass.
	
	• "Conduct a controlled laboratory experiment to measure the mass and volume of gas produced in a chemical reaction"

	• "Conduct a practical investigation to demonstrate the law of conservation of mass by modelling the rearrangement of atoms in a reaction"
	  ○ Unclear whether this is lab practical vs 2D/3D modelling – is it deliberately open?
	  ○ Many teachers will read 'practical investigation' as 'lab experiment' - (with the exception of the addition of modelling this seems to be what is intended on page 11 of syllabus). If the syllabus will use this terminology differently (more literally, practical = hands on), this needs to be specified in the glossary we mention in the general comments at the end of this document.
	
	Mole concept
	  ○ The structure of this section is much improved and follows accepts learning progression literature about the understanding of a mole.
	
	Measures of concentration
	• "Solve real-world problems using combinations of stoichiometric principles involving reacting masses and solutions"
	  ○ Introduce the term stoichiometry earlier in this section
	
	Properties of gases
	• "Use the particle theory to describe the properties of ideal gases"
	• "Justify why equal numbers of moles of ideal gases occupy the same volume at the same temperature and pressure"
	    ○ Is there a reason gas laws are not included here?
	
	Chemical reactions
	
	Classifying chemical reactions
	• Discuss features and predict the products of synthesis, decomposition, combustion, precipitation and neutralisation reactions using balanced equations
	  ○ This is a huge outcome, suggest that it is re written to show how complex this dot point is.

    - Suggest split into five different dot points, one for each reaction type.

Rates of reactions

- "Plan and conduct a laboratory experiment to accurately measure the effect of concentration, temperature, surface area or catalysts on the rate of a chemical reaction"
- "Explain the role of activation energy, molecular orientation and the frequency of successful collisions of particles in collision theory"
- "Analyse how concentration, temperature, surface area and catalysts affect reaction rate using collision theory"
    - Rearrange this to avoid discovery learning. Start with "explain" then "plan" and "conduct" then "analyse".

Energy changes

- "Explain how Aboriginal firestick methods are examples of exothermic reactions"
    - This looks tacked on – maybe you can strengthen this with a relationship to exploring natives and the impact of native combustibles.
- "Model the effect catalysts have on activation energy in endothermic and exothermic reactions"
- "Conduct a secondary-source investigation about the environmental advantages of using a catalyst on an industrial process"
    - Suggest catalysts belong in "Rate of Reaction".

Equilibrium

Dynamic equilibrium

- "Account for the characteristics of a dynamic equilibrium using collision theory"
- "Explain why concentrations remain constant at equilibrium"
    - These should be the first outcomes – then they explore by research, models or investigations.
    - This is much better without static equilibrium.

	Factors that affect equilibrium
	• "Outline Le Chatelier's principle"
	• "Use Le Chatelier's principle to predict the effects of temperature, concentration, volume and pressure changes on equilibrium systems"
	• "Conduct a controlled laboratory experiment to analyse temperature and concentration changes in a system at equilibrium"
	• "Use collision theory to qualitatively explain the effect of concentration and temperature changes on equilibrium systems"
	  ○ This structure works well.
	
	Calculating the equilibrium constant
	• "Deduce equilibrium expressions in terms of the equilibrium constant (Keq) for reactions occurring in homogeneous solution equilibrium systems and homogeneous gas equilibrium systems"
	  ○ Is deduce the best verb here?
	
	Solution equilibria
	• **"**Assess the accuracy of the experimentally derived solubility rules by comparing them to secondary source information"
	○ This is a welcome addition, as students will learn about how scientific 'rules' are derived.
	
	• "Conduct a laboratory experiment to apply solubility rules and identify 2 unknown cations in the same solution"
	• "Conduct a laboratory experiment to apply solubility rules and identify 2 unknown anions in the same solution"
	  ○ This feels overly structured when we miss simple outcomes like explain or describe
	
	Acid–base reactions
	
	Properties of acids and bases

	• Use Brønsted–Lowry theory to recognise conjugate acid–base pairs and amphiprotic substances • Use Brønsted–Lowry theory to explain the difference between amphiprotic, monoprotic, diprotic and triprotic acids using balanced chemical equations Do these belong in the next section? Using Brønsted–Lowry theory • Analyse the relationship between pH and hydrogen ion concentration ([H+]) Should this be before the calculation? H+ has been introduced in the previous section. GF agree, looking at the theoretical relationships before moving to the calculation will help with understanding not just rote learning the calculation. What is meant by analyse here? Quantitative analysis • Plan and conduct a laboratory experiment to analyse the concentration of an unknown strong acid and an unknown strong base and assess the accuracy, reliability and validity of the results Is there a reason we aren't using the word titration? We suggest using the terminology titration as it allows for clear communication about these pracs, and helps teachers to find information about what experiments to conduct (titration being a key word used to describe these types of experiments!) **Organic chemistry** **Hydrocarbons** • Conduct a risk assessment to correctly handle and dispose of gaseous and liquid hydrocarbons This is a very specific task – interesting how this is going to look in a lesson....is the plan to embed into the practical? Some schools have Risk Assess and ChemWatch – others do not. How do we ensure parity here. Some schools also don't have access to appropriate waste disposal for the hydrocarbons referred to here.

	Alcohols
	
	Esters
	• "Analyse the use of esterification reactions in the condensation polymerisation process to produce polyester polymers"
	    o What does analyse mean here? Analyse should mean talking about pros, cons, whereas this content should probably be a describe or outline.
	
	Applying Chemical Ideas
	
	Analysis and use of organic substances
	Gas Chromatography
	o Why gas chromatography? Why not other forms of chromatography? Look to SACE syllabus - TLC - use known concepts (intermolecular bonding) to understand how TLC works and some schools have access to TLC, used by synthetic chemists to monitor reactions, access for all students if they came into a university for a program, and TLC helps students understand basic concepts for other forms of Chromatography.
	o Not needed for first year students coming in. Also, why add more complex analytical techniques when teachers are only just getting their heads around spectroscopic techniques?
	o Old syllabus has chromatography as an option, then there was no chromatography, but it's used widely in chemistry in universities, it was an example of something that could come in with mass spectrometry
	o Not adding understanding of science in the real world
	o Some of the mass spec and NMR belong in tertiary?
	
	• "Interpret experimental, mass spectroscopic, proton (1H) and carbon (13C) NMR spectra and GC–MS data to deduce the structures and structural features of simple organic compounds"
	    o How will schools get access to experimental spectra? These are often messy and very difficult to understand, compared to the neat spectra analysed when

	learning these skills. Also, universities will not often run simple compounds through NMR or MS, as they are bought.
	○ Suggest removing experimental.
	
	Working Scientifically
	○ "Select qualitative and quantitative information from texts, diagrams, flow charts, tables, databases, graphs and multimedia resources"
	  ○ Unclear what this means.
	
	• "Describe qualitative and quantitative relationships between variables"
	  ○ Unclear what this means.
	
	• "Gather information from a range of secondary sources"
	  ○ Please re-add "and acknowledge them using an accepted referencing style".
	  ○ This a skill students should be using in stage 6 in preparation for university entry and we note that the 7-10 science syllabus includes acknowledging sources, so this is a logical continuation of skills.
	
	  ○ Although many of the communication dot points seem to have increased clarity, there is no longer a point that says students should learn to communicate in a variety of contexts.
	  ○ Science communication to share their scientific knowledge is an extremely important part of scientific learning (firstly, for consolidating understanding, secondly, as a skill in its own right).
	  ○ Please add a curriculum point where students need to communicate science in a variety of contexts. This could be added to "Use evidence and correct scientific language and terminology to *communicate in a variety of contexts, and to* address a specific audience and purpose"
	
	• "Construct evidence-based arguments and engage in peer review to evaluate scientific practice, a solution or conclusion"
	    ○ This should be plural – practices, solutions, conclusions- should be an ongoing, many times rather than once.

	Maths in the Syllabus ○ There is still way too much here. It is skewed towards mathematicians rather than chemical conceptual understanding; chemistry should be accessible to students who want to do chemistry. **Mapping Stage 4,5,6** ○ It would be helpful to see a NESA map of chemistry content in Stage 4,5 to Stage 6 so teachers know what they need to revise because students haven't seen since year 7/8.
3. Are scientific investigations sufficiently flexible for implementation by teachers?	○ There is no flexibility in terms of what investigations we can run in class. They are very specific and appear to be mandated pracs. ○ Schools in Rural and Remote areas might struggle with this syllabus if they do not have adequate resources (due to the mandatory nature of practical investigations). ○ The experiments are not overly complex. The new practicals are manageable but would require buying chemicals that school labs don't use. Eg the determining mp of Group I and II chlorides. You would need to do a few to obtain good data. Having never melted NaCl I did check if this could be done using a Bunsen burner. ○ There are not too many new practicals. Esterification not mandated as an experiment – only to plan and evaluate a method.
4. Do the syllabuses provide flexibility for teachers to support diverse learners?	**Content** ○ Application to everyday life: there is some improvement of this (which is great), but not enough across most of the curriculum. This means it's up to teachers to add that in, with so much content they won't have time for this. Providing more examples would be helpful, rather than 'mandated' connections. The structure of using footnotes to clarify many of the Aboriginal and Torres Strait Islander Dot points may be useful here. ○ More inclusions of Aboriginal scientific methods and knowledges means that teachers will teach these; their specificity and the examples provided will help direct us to appropriate resources.

	Assessment ○ Depth studies still being present are a good way to support diverse learners; students can follow their interests and investigate different topics; they also make it easier for teachers to differentiate.

General Comments:

Structure (overall course)

- While it is good to be moving to 3 modules in year 11, the 120 hours teaching requirement in Year 11 is not feasible.
- Numbers (and letters) are needed to number all the headings and sections and outcomes, so that teachers all know which we are referring to.

Structure (curriculum points)

- Consistent language is needed across the syllabus for all terminology (eg. Representations and models - what is the difference? Also ‘Investigation’ and ‘demonstration’ isn’t well delineated). This will be particularly important for early career teachers.

Needs

- A glossary of terms is needed, with correct definitions
  - Particularly important to define: accuracy, reliability, validity and precision. There is a lot of confusion about these terms. These terms should be defined in the same way across all the science units.
- NESA guidance for Aboriginal & Torres Strait Islander perspectives is needed.
  - Aboriginal and Torres Strait Islander perspectives need to be taught authentically. For example: “Explain how Aboriginal firestick methods are examples of exothermic reactions” - Is there more to this?
- Resources also needed for some of the real-world contexts. For example, Mole concept, last point. Are there resources for these real-world contexts? If not, is data and information easily accessible for teachers to find and develop questions for these?

Working Scientifically

- Working Scientifically in Stage 6 needs to work with the new 7-10 syllabus. The continuum of skills does not currently isn't as smooth as it could be.
  - Go back to find specific examples to illustrate this
  - Loss of observation of WS skill (opportunity for curiosity)

- A databook is needed for Stage 6
  - What do you need in the databook? Make a list for written feedback
  - Electronegativity, bond lengths
  - Make notes on old data sheet that is no longer being used
  - To ensure details and rote learning don't mean less marks when students do understand concepts
- Have you considered adding specific requirements to consider systematic and random error in student investigations? Giving them this language to talk about different things that can go wrong in investigations, or lead to unexpected results, is important for scientific literacy.

Data

- The addition of data science in the new 7-10 is good, however there is currently no progression for data science in Stage 6. It is a shame to lose data science completely - it should not be just for science extension.
- Would like to see some continuum of 7-10 data skills in the chemistry syllabus, e.g. univariate and bivariate analysis
- Suggestions for some places this could work:
  - Periodic table trends (already included)
  - Graphing length organic chains to boiling/melting point and other physical properties
  - Electronegativity and polarity
  - Rates of reaction
  - Equilibrium
  - And others

Modelling

- Need clarity on scientific/physical / data/mathematical models.
- Lots of the dot points that say "model" seem to be making physical models. This is useful to an extent but possibly shouldn't be mandatory in so many places. It should be a suggested pedagogy that teachers can use as appropriate for their context.
- Other types of modelling should also be incorporated to help students build a robust understanding of modelling – including computational models, not always making, sometimes interacting with existing models.
- Good practice would also include students interrogating the use, utility, benefits and limitations of different models.
  - Opportunity for this in spdf orbital modelling
- It's great that this has already been included in the following points:
  - "Evaluate how models are used to illustrate the key characteristics of metallic, ionic and covalent compounds, and relate them to compounds' physical properties"

Investigations

- The balance between using pracs to demonstrate a concept versus having student do authentic scientific investigation isn't there.

- There are many points that ask students to conduct investigations, but not many investigations within the science understanding content provide opportunities to genuinely question and plan investigations that are not just 'recipe-based'; the specific investigations are helpful to enable finding resources to support teaching, but do not allow for depth of thinking for students.
- Prac that investigates a concept vs a prac that involves genuinely questioning, predicting and following the scientific method. It would be helpful and advisable to separate these things. The demonstration of concepts investigations are good but shouldn't be the only types of investigations we do.
- Depth studies are the only places where genuine authentic scientific questioning is possible; many teachers are moving away from authentic investigations in depth studies to meet exam outcomes.
- Not many opportunities to be practicing questioning and predicting.
- There should be more opportunities to solve a problem, rather than an equation.
- Opportunities for authentic scientific investigations need to be added.

Mandatory Pracs

- If the practicals will remain in this format, where they appear mandatory, schools will need support. This includes examples of pracs that all schools could access, even in rural and remote settings.

With an aim to make a basic list of laboratory equipment and chemicals schools teaching Stage 6 chemistry should have

Examples:

- "Conduct a controlled laboratory experiment to measure the mass and volume of gas produced in a chemical reaction "
    - Production of carbon dioxide, capture in balloons
    - Loss of mass in a bubbling experiment

Other:

- Resoundingly – fix this statement and ensure consistency throughout

Suggestion:

- *Practical investigations include:*
- *undertaking laboratory experiments,*
- *computer simulations,*
- *modelling,*
- *fair tests,*
- *processing and analysing primary **or secondary** data,*

- *using appropriate digital technologies* ***OR***
- *fieldwork.*

o *Secondary-source investigations include:*

- *locating and accessing a wide range of secondary data and information*
- *analysing, using and reorganising secondary data and information (?remove if included above?)*
- *extracting and reorganising secondary-source information in the form of flow charts, tables, graphs, diagrams, prose, keys, spreadsheets and databases*
- *using models to inform understanding.*

o Explicit structure for investigations needed.