12.Dec.12 TLO 2.1. collation of group statements collected

Instructions to 12.12.12. Discussions

The primary goal of this meeting is to identify the key ideas and understandings that underpin each of the 'Principles and concepts of chemistry' (Chemistry TLO 2.1), then to generate a series of statements (no more than FIVE) that encapsulate the identified key ideas and understandings. The statements need to be coherent and integrated and MUST be assessable. The series of statements produced under each of the 'Principles and concepts of chemistry' will be circulated nationally for comment.

The aim is to identify the core outcomes, knowledge and skills that we as a disciplinary community expect a PASS LEVEL graduate of a Bachelor level program with a Chemistry focus to be able to demonstrate. It is NOT intended that we arrive at a detailed prescriptive ("standardised") curriculum.

Your task as a group:

1. For the TLO, identify as many underlying concepts as you can.
2. Draw together NO MORE THAN FIVE key ideas and understandings that underpin the TLO.
3. Write a statement that encapsulates each of these key ideas and understandings. Submit these by using the online form (link given on each worksheet).

You will have 15-20 minutes to complete this task. This will be followed by a 10-15 minute synthesis of ideas from all the groups present.

NOTE: in the tables for TLO2.1.1-7; minor edits have been made, either highlighting issues / comments or moving /copying text.

TLO 2.1.1 Stoichiometry, structure and characteristic properties of chemical substances

Group:	1	2	3	4	Further comments
statements 1: *Summarise the common themes of these concepts in no more than five key ideas and understandings:*	1. mole concept 2. periodicity 3. models of bonding 4. quantisation of energy 5. quantitative skills (related to mole concept?)	1. Periodic table's structure and trends (periodicity) 2. Atomic structure and properties (quantum description, A.O.'s) 3. Bonding - covalent / ionic →compounds →chemical formulas 4. Stoichiometry - mole concept/molarity 5. chemical formulas and chemical equations, eg. Balancing equations		1. Major aspects of chemical terminology, representations, nomenclature, convention and units 2. Quantum mechanics describes interaction of electrons and nuclei in bonding and interatomic interactions. Applies to description of structure of atoms and molecules (Eurobach number 6 "The principles of quantum mechanics and their application to the description of the structure and properties of atoms and molecules.") 3. Eurobach number 9 "The characteristic properties of elements and their compounds, including group relationships and trends within the Periodic Table" 4. Eurobach number 10 "The structural features of chemical elements and their compounds, including stereochemistry" 5. Atoms are conserved in chemical / physical change (with exception of nuclear changes)	
Statements 2: *For each of these key ideas and understandings, formulate a statement that encapsulated the common themes. Make sure that these are assessable!*	1. The unit of measurement for expressing amounts of chemical substances is the mole. 2. elements can be organised on the basis of their [atomic number / structure] number of electrons and this can be correlated to macroscopic properties and reactivity 3. atoms may interact with each other to form more complex chemical entities (molecules) through the formation of chemical bonds 4. energy levels in atomic and molecular systems are quantised	1. The determination of atomic structure and properties though a quantum mechanical description 2. A systematic description of atomic properties and trends using the periodic table 3. The formation of chemical bonds through the atomic properties of the elements 4. Stoichiometry - get it right! / moles	1. The mole concept is a unifying concept for quantities of substances and relating quantities of substances in chemical reactions 2. Principles of electronic structure as applied to atoms and molecules to explain their properties 3. Substances can be placed on a continuum of bonding based on electronic structure (orbital theories)	1. Major aspects... provide the basis of understanding other concepts and communication 2. Quantum mechanics describes interaction of electrons and nuclei in bonding and interatomic interactions. Applies to description of structure of atoms and molecules	

TLO 2.1.2 Methods of structure determination

Group:	1	2	3	4	Further comments
statements 1: *Summarise the common themes of these concepts in no more than five key ideas and understandings:*	1. Sample preparation (purity) 2. Simple physical and chemical tests 3. Elemental analysis 4. Spectroscopy 5. Databases / standard reference materials		1. Spectroscopy - transitions between quantised levels. The spectrum probes different molecular structural aspects 2. Different levels of structure - shape, geometry, isomers, etc. - different associated techniques 3. Scattering - crystal structures 4. spectrometry - mass spec, chromatography 5. Classical quantitative / qualitative analysis - functional group tests, microanalysis 6. Relation to separation / analytical techniques	1. The principle techniques of structural investigation, including spectroscopy 2. Relating structure to a measurable properties principally based upon: 3. the interaction of EM radiation with matter, giving data interpretable in fundamental terms of structure of a chemical species 4. The importance of separation techniques to achieve a sample that can be studied 5. Making an informed choice of both separation method and structure determination method	
Statements 2: *For each of these key ideas and understandings, formulate a statement that encapsulated the common themes. Make sure that these are assessable!*	1. Consideration of sample purity and / or composition and the need for some form of sample pre-treatment 2. The structure of compounds determine their physical and chemical properties 3. The need for elemental analysis for determination of elemental analysis 4. The use of a range of spectroscopic techniques for structure elucidation 5. The use of reference databases and standard reference materials (for comparison)	1. Chemical structures can be determined by a variety of methods which give characteristic information concerning the system under study 2. Many methods are based on the interaction of EM radiation and / or fields with electrons and / or nuclei of the system under study 3. Spectroscopic methods rely on the quantisation of energy 4. Diffraction methods may rely upon wave / particle properties of the EM radiation interacting with the system under study 5. A variety of chemical processes can be used to contribute to structure determination	1. A student will appreciate that spectra arise from transitions between quantised energy levels of atoms, molecules and extended structures, and that spectra provide information on structure of these substances 2. Similar statement for scattering 3. Similar statement for spectrometry 4. A student will appreciate that classical quantitative / qualitative analysis can be used to determine functional groups and that these form the basis of many commercial 'kits' 5. A student will understand the relationship of separation (chromatography) techniques to structure determination	1. Demonstrate knowledge of the principal techniques of structural investigation, including spectroscopy 2. Relate structure to a measurable property principally based on the interaction of EM radiation with matter 3. Understand and demonstrate knowledge of appropriate separation techniques to achieve a sample that can be analysed 4. Demonstrate the capacity to make an informed choice of both separation and structure determination method	

TLO 2.1.3 Properties of matter in relation to structure

Group:	1	2	3	4	Further comments
statements 1: *Summarise the common themes of these concepts in no more than five key ideas and understandings:*			1. Electron distribution influences chemical and physical properties 2. Molecular shape influences chemical and physical properties 3. Secondary interactions strongly influence molecular, macromolecular and bulk properties	1. The principles of quantum mechanics and their application to the description of the structure and properties of chemical entities 2. Shape of chemical species influence their chemical and physical properties 3. Intermolecular forces which arise from the shape and constituent atoms are responsible for the macroscopic properties of a chemical species 4. Properties of analogous groups of compounds allowing prediction of properties of unknown compounds 5. That matter extends beyond the molecular (including ionic compounds, giant covalent compounds)	
Statements 2: *For each of these key ideas and understandings, formulate a statement that encapsulated the common themes. Make sure that these are assessable!*	1. Interactions between atoms and molecules are electrostatic in nature and influence their properties and with the available energy define the states of matter 2. Physical properties depend on the nature of the bonding charge distribution, polarity and three dimensional arrangement 3. Chemical reactivity depends on the nature and strength of the intermolecular and intramolecular interactions within structures 4. Properties of mixtures can differ from those of the components 5. Properties can be influenced and controlled by the physical environment including temperature and pressure	1. See TLO 2.1.1 (tongue in cheek!) 2. Size, shape and electron distribution [structure] dictate chemical and physical properties and behaviours [properties]	1. Electron distribution influences chemical and physical properties 2. Molecular shape influences chemical and physical properties 3. Secondary interactions strongly influence molecular, macromolecular and bulk properties	1. Understand the principles of quantum mechanics and their application to the description of the structure and properties of chemical entities 2. Appreciate that the shape, and constituent atoms, of chemical species influence their chemical and physical properties 3. Understand that intermolecular forces which arise from the shape and constituent atoms are responsible for the macroscopic properties of a chemical species 4. Appreciate the trends in properties of analogous groups of compounds allow prediction of properties of unknown compounds 5. Understand that matter extends beyond the molecular to include metals, ionic compounds and giant covalent compounds	

TLO 2.1.4 Chemical thermodynamics, equilibrium and kinetics

Group:	1	2	3	4	Further comments
statements 1: *Summarise the common themes of these concepts in no more than five key ideas and understandings:*		1. Distribution of energy - implications for all of thermodynamics, equilibrium and kinetics 2. State functions and path independence, changes between initial and final states 3. Kinetics depends on details of mechanism and available energy (collisions) 4. Gibbs, position of equilibrium and spontaneity are linked 5. Thermodynamic / kinetic balance 6. Equilibrium is dynamic and the position can be manipulated		1. Energy changes underlie chemical reactions - bonds breaking and forming and energetic implications 2. Relationships between free energy, enthalpy and entropy 3. Understanding a reaction profile and its implications in thermodynamic versus kinetic control 4. Understanding kinetics in terms of collision theory, elementary reactions and mechanism 5. Practical applications of equilibria: acid/base reactions, etc, solubility. Controlling reactions using temperature / catalysts / concentration	
Statements 2: *For each of these key ideas and understandings, formulate a statement that encapsulated the common themes. Make sure that these are assessable!*	1. Energy is the key currency of chemical and physical change at both the molecular and macroscopic levels 2. All chemical and physical changes are in principle reversible; in a closed system all chemical and physical changes will attain equilibrium 3. Chemical reactions have a timescale over which they occur which can be influenced by changing reaction conditions 4. Something about 'how fast versus how far'	1. Would want as threshold that students understand, apply and use the above in applications, alongside other TLOs 1. Distribution of energy - implications for all of thermodynamics, equilibrium and kinetics 2. State functions and path independence, changes between initial and final states 3. Kinetics depends on details of mechanism and available energy (collisions) 4. Gibbs, position of equilibrium and spontaneity are linked 5. Thermodynamic / kinetic balance 6. Equilibrium is dynamic and the position can be manipulated	1. Transformation from reactants to products involves energy changes over a timescale 2. Spontaneity of chemical reaction is a function of enthalpy and entropy changes 3. The overall kinetics of a reaction is determined by the chemical reaction 4. ACS anchor number 8 "Equilibrium: All chemical changes are, in principle, reversible; chemical processes often reach a state of dynamic equilibrium" 5. Chemical thermodynamics and kinetics determine the reactivity and application of chemical reactions	1. Energy changes underlie chemical reactions 2. Quantitative and qualitative relationship between free energy, entropy and enthalpy and its application to point 1 above 3. Understanding a reaction coordinate profile and its implications to thermodynamic versus kinetic control 4. as above, viz: Understanding kinetics in terms of collision theory, elementary reactions and mechanism 5. as above, viz: Practical applications of equilibria: acid/base reactions, etc, solubility. Controlling reactions using temperature / catalysts / concentration	

TLO 2.1.5 Reaction processes and synthesis which can transform substances into very different products

Group:	1	2	3	4	Further comments
statements 1: *Summarise the common themes of these concepts in no more than five key ideas and understandings:*	1. Knowledge of the mechanistic pathways allows reaction to be directed		1. Systematic ways of thinking about chemical transformations - mechanistic 2. Mechanism - every bond-breaking / bond-making / intermediates / catalytic cycles 3. Apply TLO 2.1.1, 2.1.4. In arguing for mechanism and / or planned synthesis 4. Planning reactions - ways of planning synthetic approach based on above 5. Systematic types - proton transfer / electron transfer / addition / elimination / substitution / rearrgements	1. Synthesis involved the making and breaking of bonds 2. Systematic classification of processes by general types allows prediction of outcomes and development of new methods (C-C, functional group interconversion, heterogeneous bond formation) 3. Strategic synthesis - rationally design single-step or multi-step syntheses through understanding specific reactions, including functional group interconversion and bond breaking / forming and their efficiency 4. That all synthesis involves the conversion of reactants to products →selectivity in chemical transformation	
Statements 2: *For each of these key ideas and understandings, formulate a statement that encapsulated the common themes. Make sure that these are assessable!*	1. Chemical reactions neither create or destroy matter but rearrange already present atoms 2. In a reaction existing bonds are broken and new bonds are formed to produce molecules with different properties to the reactants 3. Chemical reactivity is driven by the electronic structure and shape of the reactants 4. Reactions are directed by the mechanism and reaction pathway... 5. ...which can be controlled for a desired outcome	1. Chemical reactions involve rearrangement of atoms with associated energy changes that result in products with chemical and physical properties different from the starting reactants 2. Major types of chemical reactions and the characteristics that allow us to characterise them 3. Chemical reactions can be used in a purposeful way to achieve desired outcomes 4. Chemical reactions can be used in a purposeful way to synthesise desired products using well defined processes, including multi-step processes N.B. The wording of this TLO is not great. We suggest: *Reaction processes and syntheses leading to chemical transformation where the products have different (physical and chemical) properties from the starting materials*	1. Systematic ways of thinking about chemical transformations - mechanistic 2. Mechanism - every bond-breaking / bond-making / intermediates / catalytic cycles 3. Apply TLO 2.1.1, 2.1.4. In arguing for mechanism and / or planned synthesis 4. Planning reactions - ways of planning synthetic approach based on above 5. Systematic types - proton transfer / electron transfer / addition / elimination / substitution / rearrgements	1. Synthesis involves the making and breaking of bonds transforming reactants into products 2. Systematic classification of processes by general types allows prediction of outcomes and the development of new methods 3. Strategic synthesis: rationally designing single-step and multi-step syntheses through understanding specific reactions, including functional group interconversion and bond formation / breaking 4. Selectivity? Chemo-, regio- and stereo-specific. Solubility, combustibility	

TLO 2.1.6 Reactions of metal and non-metal compounds including carbon compounds

Group:	1	2	3	4	Further comments
statements 1: *Summarise the common themes of these concepts in no more than five key ideas and understandings:*		1. Suite of reactions / known transformations of which some have been carried out in the lab, including TLO 2.1.2, TLO 4.2, TLO 3.3 2. Reaction components used - ligands, functional groups, acids and bases, oxidants and reductants 3. Understanding of examples of biological, industrial, contemporary reactions			
Statements 2: *For each of these key ideas and understandings, formulate a statement that encapsulated the common themes. Make sure that these are assessable!*	1. ACS 5E viz: E. Chemical change can be controlled by choices of reactants, reaction conditions, or use of catalysts. 2. ACS 5F viz: F Controlling chemical reactions is a key requirement in the synthesis of new materials. 3. Chemical transformations can be rationalised by chemical mechanistic descriptions which can be used to predict novel reactions 4. ACS 5D viz: D There are a large number of possible chemical reactions, and categories have been devised to organize understanding of these reaction types. 5. Chemical transformations can be either analytical or stoichiometric	1. Suite of reactions / known transformations of which some have been carried out in the lab, including TLO 2.1.2, TLO 4.2, TLO 3.3 2. Reaction components used - ligands, functional groups, acids and bases, oxidants and reductants 3. Understanding of examples of biological, industrial, contemporary reactions.	General comments: • We think that 2.1.6 is a subset of 2.1.5 • 2.1.6 sounds suspiciously like trying to “write the curriculum” • If the intention is that 2.1.5 is more “mechanistic” and 2.1.6 is more “application” then we believe that the wording of both TLOs needs to more appropriately reflect this	1. There are many possible chemical reactions that can be classified into different categories 2. Many reactions involve transfer of electrons between chemical species 3. Reaction of metals and non-metal compounds including carbon compounds involve interactions between molecules, or region of molecules, of differing electron densities 4. The bonding capacity of carbon and its ability to bond to itself leads to the wide diversity of reactions involving carbon compounds	

TLO 2.1.7 Quantifying concentrations of elements and compounds in simple and complex mixtures

Group:	1	2	3	4	Further comments
statements 1: *Summarise the common themes of these concepts in no more than five key ideas and understandings:*				1. Concentration / definition: IUPAC definition, number per volume. Common usage of expressing concentration includes mole fraction and mixing ratio, eg. mg/kg, etc. 2. Quantification is based on a measurable parameter that is related to concentration of analyte 3. Separation and / or sample preparation my constitute and important aspect of the overall quantification process 4. Appropriate choice of quantification technique is crucial - this may include classic wet chemistry techniques (eg. Titration / gravimetric) or instrumental analysis 5. Quality assurance and quality control is an integral aspect of any quantification procedure, eg. Use of standards, blanks, calibration curves, replicate analyses etc.	
Statements 2: *For each of these key ideas and understandings, formulate a statement that encapsulated the common themes. Make sure that these are assessable!*	1. Principles of quantitative analysis: control/blank, calibration, precision/accuracy, LoD, sampling, standardisation, statistics, signal/noise ratio 2. A variety of techniques can be used to separate complex mixtures either prior to or as part of quantification 3. The choice of analytical method, both destructive and non-destructive, is dependent on the concentration of analyte present, the nature of the material and the instrumentation available 4. A variety of chemical and instrumental methods can be used to quantify analytes	1. Variety of techniques, each giving characteristic information: choice of method depends on desired selectivity / sensitivity and mixture / sample 2. Substances and / or mixtures may require separation and / or degradation into simples and / or pure substances for quantification 3. Interpret the results of a measurement in terms of concentration, quantity or other appropriate unit 4. Experimental design and data analysis to critically evaluate the reliability of the result based on reproducibility AND limitations of the measurement method 5. Understanding the details of some (not prescribed) of these techniques AND their application to quantitative analysis, as appropriate to sub sub-discipline	1. Derivation of qualitative relationship between [illegible word] and experimental measurements and reporting the results with appropriate units 2. Determination of experimental uncertainty and sources of error and their significance 3. Chemical species can be separated on the basis of their chemical and / or physical properties in order to isolate a specific species for quantification 4. Chemical species can be quantified in by a variety of chemical and / or physical means	1. Students will appreciate definitions of concentration including common usage terms (out of time)	

26.Sept.12 TLO 2.1, 3.3 collation of group statements collected

Instructions to Discipline Day Discussions

The discussions will focus on the first section of TLO 1, essentially the "body of knowledge," and the second section of TLO 2, essentially the "recognised techniques and appropriate techniques and tools," found on p 24 and 25 of LTAS Science (see documents listed below). We will approach this from two directions, (i) a discussion of the TLO statements, focussed on essential content and depth expected by the end of the degree; accounting for different themes in degree courses offered and (ii) a discussion centred around assessment tasks we would expect students to do and how these can relate back to the two TLOs. We will set up different groups to tackle these TLOs from these two different directions.

Key points to remember: (i) we are not dealing with individual unit or subject assessment, but there will be assessments among us fit for purpose or for a useful start to spark discussion' (ii) we are dealing with thresholds, students must demonstrate mastery not simply achieve 50P.

TLO (as renumbered):	TLO 2.1 CONTENT	TLO 2.1 ASSESSMENT
summary statements	a more prescriptive list is needed for this 'body of knowledge' TLO than is provided as part of the appendixes to the Chemistry TLO document working groups are required for each sub-discipline (organic, inorganic, physical, analytical) to identify what is required, threshold knowledge within their field Entry standards should be considered, as students are unlikely to do well without a good pass in yr12 chemistry and maths consider including basic maths and stats	1. 'Threshold' is above knowledge recall, it is at 'understanding' 2. Mechanisms of assessment: exams, assignments, reports, portfolios, pracs, presentations 3. Usefulness depends on structure of assessment and nature of student 4. Are reflective processes more useful? 5. Is demonstration of higher-order knowledge sufficient? 6. Is genuine problem solving above the threshold?

TLO (as renumbered):	TLO 3.3 CONTENT	TLO 3.3 ASSESSMENT
summary statements	1. Two broad sets of skills are needed: measurement and analysis; synthesis and isolation 2. Critical observation and recording is very important 3. Students should be able to apply a procedure, not just blindly follow instructions 4. Do they need to be able to design an experiment? If so, at what level? 5. How to assess? 6. What to do if the graduate does not meet the threshold?	1. TLO reporting requirement – portfolio assessment across 3 years. Use consolidation of assessment 2. Usefulness for students – electronic system required, gives student a choice about evidence 3. Multiple opportunities for students to satisfy TLOs