This document has an identifier next to each testable SU concept to be used for referencing.

Subtopic 3.1: Introduction

| Science Understanding | Reference |
| --- | --- |
| Organic compounds can be represented by molecular and structural formulae.   * Determine the molecular formula of an organic compound given its extended, condensed, or skeletal structural formula.   Organic compounds are named systematically to provide unambiguous identification.  Condensation reactions occur when two organic molecules combine to form a larger molecule, also releasing another small molecule, such as water. | 2.3.1.1 |
| The physical properties of organic compounds are influenced by the molar masses of the molecules, and the number and polarity of functional groups.   * Predict, explain, and compare the melting points, boiling points, and solubilities in water and in non-polar solvents of organic compounds, given their structural formulae. | 2.3.1.2 |

Subtopic 3.2: Alcohols

| Science Understanding | Possible Contexts |
| --- | --- |
| Alcohols are classified as primary, secondary, or tertiary.   * Identify, name systematically, and draw structural formulae of alcohols containing: * up to eight carbon atoms in the main chain, with side chains limited to a maximum of two carbon atoms * one or more hydroxyl groups.   Primary, secondary, and tertiary alcohols behave differently with oxidising agents.   * Describe how primary and secondary alcohols can be distinguished from tertiary alcohols by their reaction with acidified dichromate solution. * Predict the structural formula(e) of the product(s) of oxidation of a primary or secondary alcohol, given its structural formula. | 2.3.2.1  2.3.2.2  2.3.2.3 |

Subtopic 3.3: Aldehydes and ketones

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Aldehydes and ketones are produced by the oxidation of the corresponding primary and secondary alcohols respectively.   * Identify, name systematically, and draw structural formulae of aldehydes and ketones containing: * up to eight carbon atoms in the main chain, with side chains limited to a maximum of two carbon atoms * one or more aldehyde or ketone groups.   Aldehydes can be readily oxidised; ketones cannot.   * Draw the structural formula of the oxidation product of a given aldehyde in either acidic or alkaline conditions. * Describe how acidified dichromate solution and Tollens’ reagent (ammoniacal silver nitrate solution) can be used to distinguish between aldehydes and ketones. | 2.3.3.1  2.3.3.2  2.3.3.3 | |

Subtopic 3.4: Carbohydrates

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Carbohydrates are naturally occurring sugars and their polymers. They are defined as either polyhydroxy aldehydes or polyhydroxy ketones, or substances that form these compounds on hydrolysis.   * Given its structural formula, determine whether a molecule is a carbohydrate.   Disaccharides and polysaccharides are produced by the condensation of monosaccharide units linked in chains by covalent bonds.   * Write molecular formulae for glucose, and for disaccharides and polysaccharides, based on glucose monomers. * Draw the structural formulae of the monosaccharide(s), given the structural formula of a disaccharide. * Identify the repeating unit and draw the structural formula of the monomer, given the structural formula of a section of a polysaccharide.   In aqueous solution there is an equilibrium between a ring form and a chain form of glucose.   * Explain the ability of glucose to react as an aldehyde when in chain form but not when in ring form. | 2.3.4.1  2.3.4.2  2.3.4.3  2.3.4.4  2.3.4.5 | |

Subtopic 3.5: Carboxylic acids

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Carboxylic acids can be produced by the oxidation of aldehydes or primary alcohols.   * Identify, name systematically, and draw structural formulae of carboxylic acids containing: * up to eight carbon atoms in the main chain, with side chains limited to a maximum of two carbon atoms * one or two carboxyl groups.   Carboxylic acids are weak acids and, to a small extent, ionise in water.   * Write equations for the reactions of carboxylic acids with bases, including hydroxides, carbonates, and hydrogencarbonates, to form carboxylate salts, and describe changes that accompany these reactions. * Explain why sodium and potassium carboxylate salts are more soluble in water than their parent carboxylic acids. | 2.3.5.1  2.3.5.2  2.3.5.3 | |

Subtopic 3.6: Amines

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Amines are classified as primary, secondary, or tertiary.   * Identify, name systematically, and draw structural formulae of primary amines containing: * up to eight carbon atoms in the main chain, with side chains limited to a maximum of two carbon atoms * one or more amino groups.   Amines act as bases.   * Draw the structural formula of the protonated form of an amine, given the structural formula of its molecular form, and vice versa. * Explain why the protonated form of an amine is more soluble in water than its parent molecular amine. | 2.3.6.1  2.3.6.2  2.3.6.3 | |

And I was going to do the the Stage 1 Dependencies as well but it’s starting to seem abit over the top, so I stopped, but I’ll leave them here so I can go back and do it later. It also helps explain the prefix “2.” On all the stage 2 SU references, because the intention was to prefix all the stage 1 references with “1.”.

Subtopic 2.2: Bonding between atoms

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| The formation of bonds between atoms results in stable valence-shell configurations.  Energy is released when bonds are formed. Energy is required to break bonds.  Metallic, ionic, and covalent bonds are the strong forces of attraction (primary bonds) between particles. | 1.2.2.1 | |
| Metallic Bonding  Metallic bonding is the force of attraction between metal cations and their delocalised valence electrons.  The physical properties of metallic elements can be explained using the model for metallic bonding.   * Explain the melting and boiling points, and electrical conductivities of metallic elements. |
| Ionic Bonding  Valence electrons are transferred from a metallic atom to a non-metallic atom to form ions. Ionic bonding is the force of attraction between the oppositely charged ions.   * Predict the charge on the monatomic ion formed by an element, using its position in the periodic table. * Write the electron configuration, using subshell notation of the monatomic ion of any of the first 38 elements of the periodic table.   Ionic compounds are continuous and are represented by empirical formulae.   * Write formulae for ionic compounds given the charges on the ions. |
| The properties of ionic compounds can be explained using the model for ionic bonding.  Explain the melting and boiling points, and electrical conductivities of ionic compounds. |
| Covalent Bonding  Non-metallic atoms share electrons to form covalent bonds.   * Use electron-dot diagrams and structural formulae to show covalent bonds between non-metallic atoms.   A covalent bond may be polar or non-polar.   * Use electronegativity values, or the position of atoms in the periodic table, to predict and explain the polarity of a covalent bond. * Indicate the polarity of a covalent bond, using the appropriate convention. | Note that the term ‘Lewis structure’, to refer to a structural formula, is used ambiguously in texts.  Use appropriate conventions to show covalent bonds and their polarities. |  |
| Covalent bonding is found in molecular and non-molecular (continuous) substances.  A molecule can be represented by a molecular formula.  A continuous covalent substance is represented by an empirical formula.  The physical properties of continuous covalent substances can be explained using the model for covalent bonding.   * Explain the melting point, hardness, and electrical conductivity of continuous covalent substances. | Investigate why carbon fibre has replaced metal in the construction of F1 cars:  <http://formula1.about.com/od/car1/a/carbon_fiber.htm>  Explore and explain the properties of graphite in ‘lead’ pencils.  Investigate the occurrence, structures, physical properties, and uses of the allotropes of carbon.  Silicon is more abundant in the Earth’s crust than carbon. Discuss reasons why our biosphere is based on carbon and not on silicon.  Write formulae for simple molecular substances given their systematic names. |  |

Subtopic 3.2: Interactions between molecules

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| The physical properties of molecular substances can be explained by considering the nature and strength of the forces of attraction between the molecules.  Secondary interactions between molecules are much weaker than primary metallic, ionic, and covalent bonds.  The shape, polarity, and size of molecules can be used to explain and predict the nature and strength of secondary interactions.  Dispersion forces exist between all molecules. Their strength depends on the size and shape of the molecules. | Note that the ion–dipole interaction is introduced in subtopic 4.2.  Compare boiling points of the halogens and of the noble gases.  Recognise that dispersion forces are often referred to as London dispersion forces in recognition of the work of Fritz London.  View the animation of hydrogen bonding in water at:  [www.sciencephoto.com/media/609850/view](http://www.sciencephoto.com/media/609850/view)  Discuss how hydrogen bonding between base pairs in the DNA strands leads to the stability of the DNA double-helix structure. |  |
| Dipole–dipole interactions exist between polar molecules and their strength depends on the polarity and size of the molecules.   * Predict the relative strengths of interactions between molecules, given relevant information.   Hydrogen bonding is a particularly strong form of dipole–dipole interaction that exists between molecules.   * Draw diagrams showing partial charges and hydrogen bonding between HF, H2O, and NH3 molecules. * Explain the boiling points of HF, H2O, and NH3 in terms of hydrogen bonding between the molecules. | Explore the effect of hydrogen bonding on the strength of interactions by plotting boiling points of the covalent hydrides of period 2 elements. |  |
| Investigate the effect of the number of O‑H bonds in a molecule on the strength of the hydrogen bonding, by comparing the rate at which a small ball sinks in test tubes containing propan-1-ol, propane‑1,2‑diol and propane-1,2,3-triol. |  |

Subtopic 3.3: Hydrocarbons

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Carbon forms hydrocarbon compounds, including alkanes and alkenes. The physical properties of hydrocarbons depend on the size of the molecules.   * Compare the melting and boiling points of hydrocarbons, given relevant information. | Explore the influence of molecular size on the strength of secondary interactions, by plotting the boiling points of hydrocarbons.  View the interactive animations of fractional distillation, such as:  [www.footprints-science.co.uk/flash/ Fractional%20distillation.swf](http://www.footprints-science.co.uk/flash/%20Fractional%20distillation.swf)  [www.chem-ilp.net/labTechniques/ FractionalDistillationlAnimation.htm](http://www.chem-ilp.net/labTechniques/%20FractionalDistillationlAnimation.htm) |  |
| Demonstrate the process of the distillation of petroleum and compare the physical properties of the fractions produced.  Compare the volatility, viscosity, and solubility in water and ethanol, of petrol, kerosene, and car oil. |  |
| Hydrocarbons are used as fuels and as feedstock for the chemical industry.   * Write equations for the complete combustion of hydrocarbons. | Explore the range of uses of materials derived from the extraction and processing of petroleum.  Debate the claim that burning oil in a car is like burning dollar bills in a fireplace. |  |
| Compare the sootiness of a flame of a small hydrocarbon (e.g. Bunsen-burner flame) and a long-chain hydrocarbon (e.g. candle flame). |  |
| Investigate the contribution of the work of chemists such as Wöhler, Perkin, and Kekulé on the rapid development of organic chemistry and how this knowledge has influenced modern chemistry.  Describe the effect that discoveries in organic chemistry have had on the development of drugs by the pharmaceutical industry. |  |
| The chemical reactions of hydrocarbons are determined by the functional groups present.   * Predict the product of an addition reaction of an alkene. | Compare the behaviour of cyclohexane and cyclohexene with bromine or iodine solution. |  |

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Hydrocarbons can be represented by empirical formulae, molecular formulae, and structural formulae, including extended, condensed, and skeletal representations.  Hydrocarbons can exist as different structural isomers.  Hydrocarbons are named systematically to provide unambiguous identification.  The structural formula of a hydrocarbon can be deduced from its systematic name.   * Identify, name systematically, and draw structural formulae of hydrocarbons containing: * up to eight carbon atoms in the main chain, with side chains limited to a maximum of two carbon atoms * one or more alkene groups. | Use information on the composition of a compound and molar mass to determine the empirical and molecular formulae of hydrocarbons. |  |
| Model hydrocarbons and their isomers, using molecular model kits or software. |  |
| Recognise that collaboration of international scientists resulted in the IUPAC nomenclature, which is an example of an international scientific protocol that facilitates clear communication globally. |  |
| Organic molecules have a hydrocarbon skeleton and can contain functional groups. | Note that teachers may consider introducing some of the functional groups included in Stage 2.  Determine the boiling points of methanol, ethanol, and propanol with a closed capillary.  Prepare a range of esters and compare their odours with the parent carboxylic acids. |  |

Subtopic 3.4: Polymers

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Polymers or macromolecules are very large molecules composed of small repeating structural units.   * Identify the repeating unit of a polymer, given the structural formula of a section of a chain. | Explore the influence of molecular size on the strength of secondary interactions, by plotting the boiling points of hydrocarbons.  View the interactive animations of fractional distillation, such as:  [www.footprints-science.co.uk/flash/ Fractional%20distillation.swf](http://www.footprints-science.co.uk/flash/%20Fractional%20distillation.swf) |  |
| Addition polymerisation occurs when monomer molecules link without the loss of atoms.  Addition polymers can be synthesised from alkene monomers.   * Draw the structural formula of an addition polymer that could be produced from monomers containing one  carbon–carbon double bond, given the structural formula(e) of the monomer(s) or vice versa. | Note that condensation polymers are considered in Stage 2 subtopics 3.7 and 3.8. |  |
| Organic polymers have diverse properties and uses.  The properties of organic polymers depend on the interactions between the polymer chains. | Note that this subtopic builds on concepts of covalent bonding introduced in Topic 2, and secondary interactions introduced in Topic 3.  *Note that properties of polymers are also discussed in Stage 2, subtopic 4.4.*  Explore the positive and negative aspects of the use of additives to improve the properties of polymers.  Discuss how and why the vulcanisation of natural rubber improves its properties.  Make PVA ‘slime’ or plastic from potatoes. |  |
| Collect information about common plastics, including monomers, properties, uses, and recycling possibilities.  Model polymer chains with paper clips, to compare tangling of chains of different lengths, and the ability of chains with and without cross-links between the chains to slip over each other.  Distinguish between HDPE and LDPE, using a 50:50 solution of ethanol and water. |  |
|  | Explore the benefits and unintended consequences of innovative polymers such as hydrogels and smart materials.  Discuss the economic, social, and environmental considerations for producing polymers from renewable materials. |  |

Subtopic 4.1: Miscibility and solutions

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Solvents can be considered as polar (e.g. water, methanol) or non-polar (e.g. hexane, turpentine, petrol).   * Identify water as a polar solvent and hydrocarbons as non-polar solvents.   Polar and non-polar solvents do not readily mix.   * Identify a solvent as polar or non-polar, based on its miscibility with water and hydrocarbons. | Explain the need to use appropriate solvents to clean paint brushes. |  |
| Mix different liquids and examine their properties in terms of their bonding.  Make a simple lava lamp and explain the effect, e.g. see:  [www.mcchesneychemistry.weebly.com/uploads/2/2/9/3/22938812/chemmattersapr1997.pdf](http://www.mcchesneychemistry.weebly.com/uploads/2/2/9/3/22938812/chemmattersapr1997.pdf) |  |
| Highly polar molecular substances are more soluble in water than non-polar molecules of a similar size.  Molecular substances with small molecules are more soluble in water than larger molecules of similar polarity.   * Predict, given the structural formulae, which of two compounds would be more soluble in polar and non-polar solvents. | Compare the solubilities of methane, hydrogen fluoride, and ammonia in water.  Discuss why ethanol can be mixed with petrol (E10 fuel) but methanol will not mix with petrol. |  |
| Compare solubilities of glucose, sucrose, and starch.  Compare solubilities of alcohols in water and a non-polar solvent, e.g. hexane. |  |
| Compounds with non-polar and polar or ionic components facilitate the mixing of polar and non-polar substances. | Explore the use of:   * detergents in froth flotation of minerals * lecithin in eggs to allow the mixing of oil and vinegar in mayonnaise * emulsifiers to prevent immiscible components from separating in foods and cosmetics. |  |
| Make a sample of cold-cream cleanser. |  |

Subtopic 4.2: Solutions of ionic substances

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Many ionic substances are soluble in water. This is particularly so for ammonium and alkali metal salts.   * Describe the formation of ion-dipole interactions when ionic substances dissolve in water.   Equations can be written to represent the dissociation and hydration of ions that occurs when ionic substances dissolve in water.   * Write equations for the dissolving of ionic substances in water. | Note that this extends the concept of secondary interactions introduced in Topic 3.  Test solubility of different ionic substances in water and other liquids. |  |
| Design an experiment to investigate the effect of particle size on the rate of dissolving. |  |
| Some ionic substances are not very soluble in water; such substances form as precipitates when solutions containing the relevant ions are mixed.   * Write ionic equations for precipitation reactions. * Explain why soap forms a scum in water containing calcium ions. | Undertake problem-solving activities to identify unknown solutions  Discuss the use of precipitation in chemical analysis.  Discuss the impact of hard water on the effectiveness of soap. |  |
| Prepare some substances by precipitation (e.g. barium sulfate, silver chloride, copper hydroxide, copper carbonate).  Undertake simple analysis using precipitation.  Prepare precipitates representing football club colours. |  |
| Explore the development of detergents in response to biodegradability and reduction of precipitates during cleaning. |  |

Subtopic 5.2: Reactions of acids and bases

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| The oxides of non-metals are commonly acidic and generate oxyacids when dissolved in water.   * Draw structural formulae for CO2, SO2 and SO3, H2SO3, H2SO4, and H3PO4. * Write equations for the reactions with water of CO2, SO2, SO3, and P4O10.   Metal oxides are commonly basic.   * Write equations for the reactions with water of Na2O, K2O, and CaO. | *Note that the expansion of the octet extends the concept of bonding introduced in subtopic 3.1.* |  |
| Similarities in the reactions of different acids with bases (metal oxides, hydroxides, and carbonates) allow products to be predicted from known reactants.  Neutralisation is an exothermic reaction.   * Identify the products obtained and write full and ionic equations for reactions between a given acid and a nominated metal oxide, hydroxide, carbonate, or hydrogencarbonate. * Undertake stoichiometric calculations for reactions between acids and bases. | Explore uses of acidic and basic chemicals in the home. Examples could include antacid preparations; phosphoric acid, oxalic acid, and vinegar for rust removal; and baking powder in cooking. |  |
| Explore reactions of acids with metal oxides and carbonates. Observe solid metal oxides and carbonates forming solutions during reactions with acids.  Demonstrate that there is a limit to how much base (e.g. copper carbonate, copper oxide, zinc oxide) will react with a given quantity of acid, to test the concept of excess reagent.  Use an indicator to observe the process of neutralisation between an acid and a base.  Explore energy changes in neutralisation reactions.  Make copper sulfate crystals from copper oxide and sulfuric acid, or from copper carbonate and sulfuric acid.  Undertake titrations to investigate acid content in beverages.  Participate in the RACI Titration Competition.  Make sherbet to explore an acid–base reaction.  [www.csiro.au/en/Education/DIY-science/ Chemistry/Sherbet](http://www.csiro.au/en/Education/DIY-science/%20Chemistry/Sherbet) |  |
| The strength of acids is explained by the degree of ionisation in aqueous solution. | Complete an exercise about strength and concentration of acids:  <http://media.rsc.org/Misconceptions/Miscon%20acid%20strength.pdf>  Test the conductivity of aqueous solutions of ethanoic, ethanedioic, hydrochloric, nitric, and sulfuric acids, and compare with the conductivities of the pure substances. |  |

Subtopic 6.1: Concepts of oxidation and reduction

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| A range of reactions, including reactions of metals, combustion, and electrochemical processes, can be considered as redox reactions. | Use gas jars to demonstrate burning iron (steel wool), magnesium, sulfur, and phosphorus in oxygen or chlorine.  Demonstrate fireworks reactions using KClO3 and sugar.  Demonstrate the combustion of gun cotton. |  |
| View ‘Redox Reactions: Crash Course Chemistry #10’:  [www.youtube.com/watch?v=lQ6FBA1HM3s](http://www.youtube.com/watch?v=lQ6FBA1HM3s)  Investigate rusting and metal corrosion as examples of oxidation. |  |
| Oxidation and reduction can be defined in terms of combination with oxygen, transfer of electrons, or change in oxidation number.   * Identify oxidation and reduction in given equations. * Write oxidation and reduction half-equations, in neutral and acidic conditions, given reactant and product species. * Combine half-equations to write a chemical equation. * Determine the oxidation states of atoms in elements and monatomic ions, and in compounds and polyatomic ions. | Discuss the similarities of combining magnesium with oxygen and with chlorine to extend the definition of oxidation to losing electrons.  Discuss the similarities of combining sulfur or phosphorus with oxygen or chlorine to introduce oxidation number.  Consider why oxidation number is not used in organic chemistry, and why the concept of gain and loss of oxygen and hydrogen is more useful.  Discuss the use of metal hydrides in batteries in hybrid vehicles. |  |
| Use test reactions to observe changes to confirm species that have reacted, such as MnO4, Cr2O72, H2O2, and Fe2+. |  |
| Discuss the development of redox concepts as scientific evidence emerged, starting with oxidation as a process involving oxygen to the current understanding of redox reactions. |  |