

Oxford Living Chemistry Grade 12 syllabus coverage grid

The following table provides a summary of the learning content for the NCCS syllabus for Chemistry AS Level, and indicates how this series covers all topics, sub-topics and objectives of the syllabus.

Theme 1 The particulate nature of matter and stoichiometry

Topic, sub-topic and objectives	LB pages	TG pages
Topic 1.1: Atoms, molecules and stoichiometry	4–21	26–32
Sub-topic 1.1.1: Relative masses of atoms and molecules	5–7	27
<i>General objective:</i> <ul style="list-style-type: none"> Know relative atomic, isotopic, molecular and formula masses <i>Specific objective:</i> <ul style="list-style-type: none"> Define and use the terms relative atomic, isotopic, molecular and formula masses, based on the ^{12}C scale 	5–7	27
Sub-topic 1.1.2: The mole and the Avogadro constant	8	27–28
<i>General objective:</i> <ul style="list-style-type: none"> Know the mole and Avogadro constant <i>Specific objective:</i> <ul style="list-style-type: none"> Define and use the term mole in terms of the Avogadro constant 	8	27–28
Sub-topic 1.1.3: Relative atomic masses	9–11	28
<ul style="list-style-type: none"> <i>General objective:</i> Understand mass spectra and calculate relative atomic mass <i>Specific objectives</i> Analyse mass spectrums in terms of isotopic abundances (knowledge of the working of the mass spectrometer is not required) Calculate the relative atomic mass of an element given the relative abundances of its isotopes, or its mass spectrum Calculate the percentage by mass of an element in a compound 	9–11	28
Sub-topic 1.1.4: Empirical and molecular formulas	12–15	28–29
<ul style="list-style-type: none"> <i>General objective:</i> Know and calculate molecular and empirical formulae <i>Specific objectives</i> Define and use the terms empirical and molecular formula Calculate empirical and molecular formulas using combustion data or composition by mass 	12–15	28–29
Sub-topic 1.1.5: Reacting masses and volumes	16–19	29–31
<ul style="list-style-type: none"> <i>General objective:</i> Know how to construct balanced equations and apply these to stoichiometric calculations <i>Specific objectives</i> Write and construct balanced equations, including state symbols Perform calculations, including use of the mole concept, involving reacting masses (from formulas and equations), volumes of gases at rtp and stp (e.g. in the burning of hydrocarbons), and volumes and concentrations of solutions 	16–19	29–31
Topic 1.2: Atomic structure	22–35	33–36
Sub-topic 1.2.1: Particles in the atom	23–25	33–34
<i>General objective:</i> <ul style="list-style-type: none"> Know protons, neutrons and electrons, their distribution in the atom and their behaviour in electric fields <i>Specific objectives:</i> <ul style="list-style-type: none"> Identify and describe protons, neutrons and electrons in terms of their relative charges and relative masses Describe the distribution of mass and charge within an atom Deduce the numbers of protons, neutrons and electrons present in both atoms and ions given proton (atomic) (and nucleon (mass) numbers and charge 	23–25	33–34

Sub-topic 1.2.2: The nucleus of the atom	26–27	34
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand nucleon number and relate it to isotopes <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe the contribution of protons and neutrons to atomic nuclei in terms of proton (atomic) number and nucleon (mass) number Distinguish between isotopes on the basis of different numbers of neutrons present Recognise and use the symbolism for isotopes, A_ZX where A is the nucleon (mass) number and Z is the proton (atomic) number 	26–27	34
Sub-topic 1.2.3: Electrons: energy levels, atomic orbitals	28–33	34–36
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Know and apply the s, p and d orbitals for principal quantum numbers 1, 2, 3 and 4 <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe the number and relative energies of the s, p and d orbitals for the principal quantum numbers (shells) 1, 2 and 3 and also the 4s and 4p orbitals Describe and sketch the shapes of s and p orbitals Recall that each orbital can hold up to 2 electrons Recall the number of orbitals making up s-, p- and d- sub-shells, and the number of electrons that can fill s-, p- and d-sub-shells Describe the increase in energy between quantum numbers (shells) 1, 2 and 3 and between the s, p and d subshells in each shell Describe how electrons fill orbitals: <ul style="list-style-type: none"> up to subshell 4d, including the filling of 4s before 3d (example in Fe, Fe²⁺, etc) for orbitals with the same energy, electrons occupy each orbital singly before pairing State the electronic configuration of atoms and ions given the proton (atomic) number and charge, using the convention 1s²2s²2p⁶, etc, and electrons in boxes representation, for example: <diagram as per syllabus> 	28–33	34–36
Topic 1.3: Chemical bonding	36–57	37–44
Sub-topic 1.3.1: Ionic bonding	37–39	38–39
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand ionic bonding <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe ionic bonding, as in sodium chloride, magnesium oxide and calcium fluoride, including the use of ‘dot-and-cross’ diagrams Describe the electrostatic forces in ionic compounds as being attraction between oppositely charged ions Describe, interpret and predict the effect of ionic bonding on physical properties (including physical state, melting point, boiling point, solubility) Explain the electrical conductivity of ionic compounds when solid, molten or in solution 	37–39	38–39
Sub-topic 1.3.2: Covalent and coordinate bonding	40–43	39–40
<p><i>General objectives:</i></p> <ul style="list-style-type: none"> Understand covalent bonding and co-ordinate (dative-covalent) bonding Understand shapes of simple molecules including bond angles and the principle of electron-pair repulsion Understand the reactions involving ligands and complexes <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe, including the use of ‘dot-and-cross’ diagrams: <ul style="list-style-type: none"> covalent bonding, including molecules such as hydrogen, chlorine, oxygen, nitrogen, hydrogen chloride, carbon dioxide, methane, ethene dative covalent (co-ordinate) bonding, including in the formation of the ammonium ion and in the Al₂Cl₆ molecule, CO, NH₄⁺, H₃O⁺ Explain the shapes of, and bond angles in, molecules by using the qualitative model of electron-pair repulsion (including lone pairs), using as simple examples: BF₃ (trigonal planar), CO₂ (linear), CH₄ (tetrahedral), NH₃ (pyramidal), H₂O (non-linear/v-shaped), SF₆ (octahedral), PF₅ (trigonal bipyramidal) Use the electron-pair repulsion theory to predict the shapes of, and bond angles in other molecules analogous to those specified in bullet 2 above (see section 4.1.2) Describe, interpret and predict the effect of covalent bonding on physical properties (including physical state, melting point, boiling point, solubility) 	40-43	39–40

Sub-topic 1.3.3: Electronegativity	44–46	40–41
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand the concept electronegativity <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Explain the concept of <i>electronegativity</i> Explain, in terms of electronegativity, the properties of molecules such as bond polarity the dipole moments of molecules and the behaviour of oxides with water 	44–46	40–41
Sub-topic 1.3.4: Intermolecular forces, electronegativity and bond properties	47–50	41–42
<p><i>General objectives:</i></p> <ul style="list-style-type: none"> Understand hydrogen bonding Understand electronegativity and its applications Understand intermolecular forces and their applications in bond properties <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe the differences between bonding (intramolecular) and intermolecular forces in covalent molecules Describe that the electrostatic forces in ionic compounds are much stronger than intermolecular forces in covalent molecules Describe that the bonding (intramolecular) forces are much stronger than intermolecular forces in covalent bonding Describe the difference in volatility, solubility, melting/boiling points and electrical conductivity between ionic and covalent compounds in terms of forces of attraction (knowledge of hybridisation is not required) Describe intermolecular forces in covalent compounds and noble gases: induced dipole (van der Waals) forces, permanent dipole forces and hydrogen bonding Explain differences in physical properties in terms of intermolecular forces, including: noble gases, Br₂(l), HCl(g), CHCl₃(l), ammonia and water as simple examples of molecules containing N–H and O–H groups State that when giant covalent substances melt, covalent bonds break and when simple molecular substances melt or boil, forces between molecules weaken Describe hydrogen bonds as the strongest intermolecular force yet still weak compared with covalent bonding Explain the effect of hydrogen bonding on the physical properties of substances, including ice, water, methane, ammonia, hydrogen fluoride and methanol (for example, boiling and melting points, viscosity and surface tension) 	47–50	41–42
Sub-topic 1.3.5: Metallic bonding	51	42
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand metallic bonding <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe metallic bonding in terms of a lattice of positive ions surrounded by delocalised electrons Describe and explain the electrical conductivity, melting point and malleability/ ductility of metals in terms of their structure and bonding 	51	42
Sub-topic 1.3.6: Bonding, structure and physical properties	52–53	42–43
<p><i>General objectives:</i></p> <ul style="list-style-type: none"> Relate different types of bonding to physical properties of substances Show understanding of lattice structures Relate hydrogen bonding to physical properties of substances <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe, in simple terms, the lattice structure of a crystalline solid which is: <as per structure detailed in syllabus and set out in book> Explain the relative energy and temperature required for changes of state in terms of the relative energy needed to break bonds (with reference to ionic, giant covalent and metallic substances) and to weaken intermolecular forces (with reference to simple covalent structures) Describe, describe, interpret and predict the effect of different types of structure and bonding ionic bonding, covalent bonding (giant and simple structures), hydrogen bonding, other intermolecular interactions, metallic bonding on the physical properties of substances, including electrical conductivity Deduce the type of bonding and structure present from given information 	52–53	42–43

Topic 1.4: The ideal gas and real gases	58–64	45–46
Sub-topic 1.4.1: Ideal and real gases and $pV=nRT$	59–61	45–46
<i>General objectives:</i> <ul style="list-style-type: none"> Show understanding of ideal and real gas and associated conditions Appreciate $pV = nRT$ <i>Specific objectives:</i> <ul style="list-style-type: none"> State the basic assumptions of the kinetic theory as applied to an ideal gas Explain qualitatively in terms of intermolecular forces and molecular size: the conditions necessary for a gas to approach ideal behaviour, and the limitations of ideality at very high pressures and very low temperatures Recall and use the general gas equation $pV = nRT$ in calculations, including the determination of M_r (NOTE: $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$) 	59–61	45–46

Theme 2 Physical chemistry

Topic, sub-topic and objectives	LB pages	TG pages
Topic 2.1: Chemical energetics	66–81	47–51
Sub-topic 2.1.1: Enthalpy change	67–74	48–49
<i>General objectives:</i> <ul style="list-style-type: none"> Understand enthalpy change and ΔH and appreciate their applications in chemical reactions Understand and interpret reaction pathway diagrams <i>Specific objectives:</i> <ul style="list-style-type: none"> Explain that chemical reactions are accompanied by energy changes, principally in the form of heat energy; the energy changes can be exothermic (ΔH is negative) or endothermic (ΔH is positive) Explain and use the terms: <i>enthalpy change of reaction</i> and <i>standard conditions</i>, with particular reference to: formation, combustion, hydration, solution, neutralisation, atomisation; and <i>bond energy</i> (ΔH positive, i.e. bond breaking) Calculate enthalpy changes from appropriate experimental results, including the use of the relationship enthalpy change, $\Delta H = -mc\Delta T$ Outline chemical reactions in terms of energy transfers associated with the breaking and making of chemical bonds Calculate energy changes for simple reactions using bond energies Explain why ΔH values from calculated bond energies differ from those obtained from data booklet and experimentally determined values 	67–74	48–49
Sub-topic 2.1.2: Hess's law	75–79	49–50
<i>General objective:</i> <ul style="list-style-type: none"> Know Hess's law and apply it in calculations <i>Specific objectives:</i> <ul style="list-style-type: none"> Apply Hess's law to construct simple energy cycles, and carry out calculations involving such cycles and relevant energy terms Apply Hess's law to determine enthalpy changes that cannot be found by direct experiment, e.g. an enthalpy change of formation from enthalpy changes of combustion Construct and interpret a reaction pathway diagram, in terms of the enthalpy change of the reaction and of the activation energy 	75–79	49–50
Topic 2.2: Electrochemistry	82–93	52–55
Sub-topic 2.2.1: Redox processes	83–87	53–54

<p><i>General objective:</i></p> <ul style="list-style-type: none"> Know redox processes and apply them in calculation of oxidation numbers and in balancing chemical equations <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Calculate oxidation numbers of elements in compounds and ions Describe and explain redox processes in terms of electron transfer and changes in oxidation number Use changes in oxidation numbers to help balance chemical equations Describe the use of aqueous potassium iodide in testing for oxidising agents and acidified potassium manganate (VII) in testing for reducing agents from the resulting colour changes Use oxidation numbers to name oxyanions, including nitrate(III) NO_2^-, nitrate(V) NO_3^-, chlorate(I) ClO^-, chlorate(V) ClO_3^- 	83–87	53–54
Sub-topic 2.2.2: Electrolysis	88–91	54
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand electrolysis and its application <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe electrolysis as the conduction of electricity by an ionic compound (an electrolyte), when molten or dissolved in water, leading to the decomposition of the electrolyte Use the concept of selective discharge to identify the electrode products of aqueous solutions to include: <ul style="list-style-type: none"> hydrogen ions and metal cations: silver, copper, (hydrogen), iron, zinc, sodium non-metal anions hydroxide and chloride in dilute and concentrated solutions Describe in outline the use of electrolysis in the extraction of metals from acidic leached solutions, for example copper and manganese Construct ionic half-equations for reactions at the cathode and anode Describe the transfer of charge during electrolysis to include: <ul style="list-style-type: none"> the movement of electrons in the metallic conductor the removal or addition of electrons from the external circuit at the electrodes the movement of ions in the electrolyte 	88–91	54
Topic 2.3: Equilibria	94–107	56–59
Sub-topic 2.3.1: Chemical equilibria: reversible reactions, dynamic equilibrium	95–102	56–58
<p><i>General objectives:</i></p> <ul style="list-style-type: none"> Understand reversible reactions, dynamic equilibrium and Le Chatelier's principle Understand equilibrium constants and apply them in calculations Understand the application of chemical equilibria in the Haber and Contact processes <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Explain, in terms of rates of the forward and reverse reactions, what is meant by a <i>reversible reaction</i> and <i>dynamic equilibrium</i> State Le Chatelier's principle and apply it to deduce qualitatively (from appropriate information) the effects of changes in temperature, concentration or pressure on a system at equilibrium State whether changes in temperature, concentration or pressure or the presence of a catalyst affect the value of the equilibrium constant for a reaction Deduce expressions for equilibrium constants in terms of concentrations, K_c, and partial pressures, K_p (treatment of the relationship between K_p and K_c is not required) Calculate the values of equilibrium constants in terms of concentrations or partial pressures from appropriate data Calculate the quantities present at equilibrium, given appropriate data (such calculations will not require the solving of quadratic equations) Explain the importance of choice of conditions (temperature, pressure, use of a catalyst) for processes used in the chemical industry including the Haber process and the Contact process, in terms of equilibrium (yield) and rate Interpret data about the conditions used in industrial processes in terms of equilibrium (yield) and rate 	95–102	56–58
Sub-topic 2.3.2: Ionic equilibria	103–105	58–59

<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand ionic equilibria in acids and bases <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Explain, and use, the Brønsted-Lowry theory of acids and bases, including the use of the acid-I base-I, acid-II base-II concept Explain qualitatively the differences in behaviour between strong and weak acids and bases and the pH values of their aqueous solutions in terms of the extent of dissociation Calculate $[H^+(aq)]$ and pH values for strong acids 	103–105	58–59
Topic2.4: Reaction kinetics	108–124	60–64
Sub-topic2.4.1: Rate of reactions	109–111	60–61
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Know rates of reactions and how concentration affects the rate of reaction <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Explain and use the term <i>rate of reaction</i> Explain qualitatively, in terms of collisions, the effect of concentration changes on the rate of a reaction 	109–111	60–61

Sub-topic 2.4.2: The effect of temperature on reaction rates and the concept of activation energy	112–114	61–62
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand how temperature affects rates of reactions <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Explain and use the term <i>activation energy</i>, including reference to the Boltzmann distribution Explain qualitatively, in terms both of the Boltzmann distribution and of collision frequency, the effect of temperature change on the rate of a reaction 	112–114	61–62
Sub-topic 2.4.3: Homogeneous and heterogeneous catalysis	115–120	62–63
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand homogeneous and heterogeneous catalysts including enzymes and their applications <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Explain and use the term <i>catalysis</i> Explain that catalysts can be homogenous or heterogeneous Explain that, in the presence of a catalyst, a reaction has a different mechanism, i.e. one of lower activation energy and interpret this catalytic effect in terms of the Boltzmann distribution Describe enzymes as biological catalysts which may have specificity Explain that reactions which use enzymes only work under specific conditions (pH and temperature) 	115–120	62–63

Theme 3 Inorganic chemistry

Topic, sub-topic and objectives	LB pages	TG pages
Topic 3.1: The Periodic Table and chemical periodicity	126–141	65–70
Sub-topics 3.1.1: Periodicity of physical properties of elements in Period 3	127–133	65–67
<p><i>General objectives:</i></p> <ul style="list-style-type: none"> Understand the periodicity of physical properties of elements in Period 3 Understand ionisation energy <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Explain and use the term <i>ionisation energy</i> Explain the factors influencing the ionisation energies of elements Describe qualitatively and explain the variations in atomic radius, ionic radius and electronegativity across Period 3 in terms of attraction, number of electrons and nuclear charge Describe qualitatively and explain the general trend in first ionisation energy across the third period in terms of attraction, nuclear charge and atomic radius (effect of paired electrons in orbitals of sub-shells is not expected) (see section 1.2.3) Describe qualitatively and explain the variations in melting point and electrical conductivity across Period 3 in terms of the simple molecular, giant molecular or metallic bonding in the elements 	127–133	65–67
Sub-topics 3.1.2: Trends in physical properties of elements down a group	127–133	65–67
<p><i>General objectives:</i></p> <ul style="list-style-type: none"> Trends in physical properties of elements down a group <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe qualitatively and explain the trends in atomic radius, ionic radius and electronegativity down Group 2 and Group 17 in terms of attraction, number of electrons, nuclear charge and degree of shielding Describe qualitatively and explain the general trend in first ionisation energy down Group 2 and Group 17 in terms of attraction, nuclear charge, atomic radius and degree of shielding (effect of paired electrons in orbitals of sub-shells is not expected) (see section 1.2.3) 	127–133	65–67

Sub-topic 3.1.3: Periodicity of chemical properties of Period 3 elements	134–137	67–68
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand the periodicity of chemical properties of elements in Period 3 <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe the reactions of Period 3 elements with oxygen (to give Na₂O, MgO, Al₂O₃, P₄O₁₀, SO₂, SO₃), chlorine (to give NaCl, MgCl₂, Al₂Cl₆, SiCl₄, PCl₅) and water (Na and Mg only) State and explain the variation in oxidation number of the oxides (sodium to sulfur only) and chlorides (sodium to phosphorus only) in terms of their valence shell electrons Describe the reactions of the oxides with water Describe and explain the acid/base behaviour of oxides and hydroxides including, where relevant, amphoteric behaviour in reaction with acids and bases (sodium hydroxide only) Describe and explain the reactions of the chlorides with water Interpret the variations and trends of the above in terms of bonding and electronegativity Suggest the types of chemical bonding present in chlorides and oxides from observations of their chemical and physical properties 	134–137	67–68
Sub-topic 3.1.4: Chemical periodicity of other elements	138	68–69
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Appreciate chemical periodicity of other elements given appropriate information <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Predict the characteristic properties of an element in a given group by using knowledge of chemical periodicity Deduce the nature, possible position in the Periodic Table and identity of unknown elements from given information about physical and chemical properties 	138	68–69
Topic 3.2: Group 2 elements	142–153	71–75
Sub-topic 3.2.1: Similarities and trends in the properties of the Group 2 metals	143–148	72–74
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand the trends in properties of the Group 2 elements, magnesium to barium, and their compounds <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe the trends in physical properties down Group 2 including melting points Describe the reactions of the elements with oxygen, water and dilute acids Describe the behaviour of the oxides, hydroxides and carbonates with water and dilute acids Describe the thermal decomposition of the nitrates and carbonates Interpret, and make predictions from, the trends in physical and chemical properties of the elements and their compounds Describe the variation in the solubilities of the hydroxides and sulfates 	143–148	72–74
Sub-topic 3.2.2: Uses of Group 2 compounds	149–151	74–75
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Appreciate the uses of calcium hydroxide and calcium carbonate in agriculture <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe the addition of water to calcium oxide (lime) to form calcium hydroxide (slaked lime) Describe and explain the use of calcium hydroxide and calcium carbonate (powdered limestone) in agriculture and manufacture of building materials (cement) 	149–151	74–75
Topic 3.3: Transition elements	154–169	76–80
Sub-topic 3.3.1: Characteristics of typical transition elements	155–159	76–77

<p><i>General objective:</i></p> <ul style="list-style-type: none"> • Know the characteristics of the first series transition elements <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> • Explain what is meant by a transition element in terms of d-block elements forming one or more ions with incomplete d orbitals • Represent the electronic configuration of transition elements using s, p, d and electrons in boxes notations (see section 1.2.3) • Recognise that transition elements have variable oxidation states, act as catalysts and form coloured compounds and that these properties are linked to their incomplete d orbitals • Contrast qualitatively the melting points and densities of the transition elements with those of, calcium as a typical s-block element 	155–159	76–77
Sub-topic 3.3.2: Extraction of transition elements from their ores	160–167	77–79
<p><i>General objective:</i></p> <ul style="list-style-type: none"> • Understand the extraction of transition elements from their ores <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> • Recognise that copper, manganese and uranium are produced from ores in Namibia • Describe the reduction by carbon of metals from their ores • Describe the use of carbon as a reducer, including in the production of (impure) copper from copper oxide and (impure) ferromanganese from a mixture of iron oxide and manganese oxide in Namibia • Describe the use of sulfuric acid as a leaching agent for example in the production of copper, manganese and uranium • Describe the extraction of pure metals, including electrolysis of leached solutions and the reduction of uranium ions using magnesium • Recognize that it is important to monitor and control waste from metal extraction including: sulfur dioxide as a pollutant product from the roasting of metal ores; waste acids from leaching processes; and toxic metal waste in water and as atmospheric particles • Discuss the finite nature of metal ores and the benefits and problems of recycling metals 	160–167	77–79
Topic 3.4: Group 17 elements	170–181	81–85
Sub-topic 3.4.1: Physical properties of the Group 17 elements	171–172	82
<p><i>General objective:</i></p> <ul style="list-style-type: none"> • Know the physical properties of Group 17 elements <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> • Describe the colours of chlorine, bromine and iodine: as vapours, at room temperature and pressure, and in solution • Describe the trend in state of chlorine, bromine and iodine at room temperature and pressure • Interpret the volatility of the elements in terms of intermolecular forces 	171–172	82
Sub-topic 3.4.2: Chemical properties of the elements and their hydrides	173–174	82–83
<p><i>General objective:</i></p> <ul style="list-style-type: none"> • Know the chemical properties of Group 17 elements and their hydrides <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> • Describe the relative reactivity of the elements as oxidising agents • Describe and explain the reactions of the elements with hydrogen • Describe and explain the relative thermal stabilities of the hydrides • Interpret these relative stabilities in terms of bond energies 	173–174	82–83
Sub-topic 3.4.3: Reactions of halide ions	175	83
<p><i>General objective:</i></p> <ul style="list-style-type: none"> • Know some reactions of halide ions <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> • Describe and explain the reactions of halide ions with: aqueous silver ions followed by aqueous ammonia; concentrated sulfuric acid 	175	83
Sub-topic 3.4.4: Reactions of chlorine with aqueous sodium hydroxide	176–177	83–84

<p><i>General objective:</i></p> <ul style="list-style-type: none"> • Understand the reactions of chlorine with aqueous sodium hydroxide <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> • Describe, in terms of changes of oxidation number, the disproportionation reaction of chlorine with cold and with hot aqueous sodium hydroxide • Describe the effects on equilibrium of changes in pH to the reactions of chlorine with sodium hydroxide 	176–177	83–84
Sub-topic 3.4.5: Uses of halogens and halogen compounds	178–179	84–85
<p><i>General objective:</i></p> <ul style="list-style-type: none"> • Appreciate some industrial applications of halogens <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> • Explain the use of chlorine in water treatment • State the industrial importance and environmental significance of the halogens and their compounds (e.g. for bleaches, PVC, halogenated hydrocarbons as solvents, refrigerants and in aerosols, see section 4.3.2) • Relate the importance of these reactions to the use of chlorine as a bleach and the treatment of water in Namibia • Relate the importance of these reactions to the use of chlorine as a bleach and the treatment of water in Namibia • • Relate the importance of these reactions to the use of chlorine as a bleach and the treatment of water in Namibia • 	178–179	84–85

Topic3.5: Nitrogen and sulfur	182–198	86–90
Sub-topic 3.5.1: Nitrogen	183–191	86–88
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Show understanding of the chemistry of nitrogen and its application in industry <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe and explain: the basicity of ammonia (see section 2.3.2); the structure of the ammonium ion and its formation by an acid-base reaction; the displacement of ammonia from its salts Comment on the depletion of nitrogen, phosphorus and potassium from soils by leaching and farming Explain the lack of reactivity of nitrogen and relate this to the need for the industrial manufacture of ammonia and its salts for use as fertilisers Describe the changes in the oxidation number of nitrogen in the nitrogen cycle in terms of the ions and molecules involved, i.e. NH_3 (-3), N_2 (0), N_2O (+1), NO_3^- (+5) State the industrial importance of ammonia and ammonium salts for use as fertilisers Explain the environmental consequences of using soluble, synthetic nitrate fertilisers, including their rapid leaching, eutrophication and possible contamination of drinking water, including from bore holes Suggest the benefits of the use of organic fertilisers in terms of their lower solubility 	183–191	86–88
Sub-topic 3.5.2: Sulfur	192–194	88–89
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Show understanding of the chemistry of sulfur and its environmental implications <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Recall that sulfur dioxide is an atmospheric pollutant formed from burning fossil fuels and from the processing of metal sulfide ores Recall that sulfur dioxide causes breathing difficulties and forms acid rain Recall the importance of the use of low sulfur fuels to keep sulfur dioxide emissions from vehicles and power stations within the World Health Organisation (WHO) limits (e.g. the van Eck coal-fired power station at Windhoek) 	192–194	88–89

Theme 4 Organic chemistry and analysis

Topic, sub-topic and objectives	LB pages	TG pages
Topic4.1: Foundations of organic chemistry	200–213	91–94
Sub-topic 4.1.1: Organic chemistry terminology	201–205	92
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Show understanding of terminology used in organic chemistry <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Interpret and use the following terminology associated with organic reactions: functional group; homolytic fission and heterolytic fission; free radical, initiation, propagation, termination; nucleophile, electrophile; addition, substitution, elimination, hydrolysis, condensation; oxidation and reduction Recall and use systematic nomenclature to name alkanes, alkenes, halogenoalkanes, alcohols, aldehydes, ketones, carboxylic acids, esters and amines, with chain length up to six carbon atoms, including: numbering the carbon atoms in a direction to give the lowest prefix possible e.g. 1-chlorobutane (not 4-chlorobutane); the use of the prefixes mono-, di-, tri-, tetra-, penta-, hexa-. 	201–205	92
Sub-topic 4.1.2: Shapes of organic molecules	206–207	92–93
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand shapes of, and bond angles in, molecules <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe and explain the shape of, and bond angles in, the ethane and ethene molecules in terms of electron pair repulsion theory (including relative length of bonds between carbon atoms) (see section 1.3.2) Predict the shapes of, and bond angles in other related molecules 	206–207	92–93
Sub-topic 4.1.3: Infrared spectroscopy	208–210	93–94
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand infrared spectroscopy and its applications <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Analyse an infra-red spectrum of a simple molecule to identify functional groups 	208–210	93–94

Topic 4.2: Hydrocarbons	214–233	95–101
Sub-topic 4.2.1: Alkanes	215–220	95–98
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand the chemistry of alkanes <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Interpret and use the general, structural, displayed and skeletal formulae of the alkanes Recall and use systematic nomenclature to name alkanes, with chain length up to six carbon atoms, e.g. 2,2-dimethyl hexane Deduce the molecular formula of alkanes, given its structural, displayed or skeletal formula Explain the general unreactivity of alkanes, including towards polar reagents Describe the chemistry of alkanes as exemplified by the following reactions of ethane: combustion; substitution by chlorine and by bromine Describe the mechanism of free-radical reactions with particular reference to the initiation (<i>homolytic fission</i>), propagation and termination reactions, including the substitution of methyl groups by halogens Explain the use of crude oil as a source of both aliphatic and aromatic hydrocarbons Explain that cracking can be used to obtain more useful alkanes and alkenes of lower <i>Mr</i> from larger hydrocarbon molecules 	215–220	95–98
Sub-topic 4.2.2: Alkenes	221–230	98–100
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand the chemistry of alkenes <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Interpret and use the general, structural, displayed and skeletal formulae of the alkenes Recall and use systematic nomenclature to name, alkenes, with chain length up to six carbon atoms, , e.g. but-1-ene, but-2-ene Deduce the molecular formula of alkenes, given its structural, displayed or skeletal formula Describe the chemistry of alkenes as exemplified, where relevant, by the following reactions of ethene and propene (including the Markovnikov addition of asymmetric electrophiles to alkenes using propene as an example): <ul style="list-style-type: none"> addition of hydrogen, steam, hydrogen halides and halogens oxidation by cold, dilute, acidified manganate(VII) ions to form the diol oxidation by hot, concentrated, acidified manganate(VII) ions leading to the rupture of the carbon–carbon double bond in order to determine the position of alkene linkages in larger molecules polymerisation Describe the concept <i>heterolytic fission</i> Describe the mechanism of electrophilic addition in alkenes, using bromine/ethene and hydrogen bromide/propene as examples Describe and explain the inductive effects of alkyl groups on the stability of cations formed during electrophilic addition Describe the characteristics of addition polymerisation as exemplified by poly(ethene) and PVC Deduce the repeat unit of an addition polymer obtained from a given monomer Identify the monomer(s) present in a given section of an addition polymer molecule Recognise the difficulty of the disposal of poly(alkene)s, i.e. non-biodegradability Describe ways/ discuss approaches to dealing with waste polymers including manufacturing of biodegradable polymers Recognise that new polymers are being developed, including biodegradable and water soluble polymers 	221–230	98–100
Sub-topic 4.2.3: Hydrocarbons as fuels	231	100–101
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Know the uses of hydrocarbons as fuels and appreciate the environmental implications thereof <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Describe and explain how the combustion reactions of alkanes led to their use as fuels in industry, in the home and in transport Recognise the environmental consequences of: carbon monoxide, oxides of nitrogen and unburnt hydrocarbons arising from the internal combustion engine and of their catalytic removal; gases that contribute to the enhanced greenhouse effect Outline the use of infra-red spectroscopy in monitoring air pollution 	231	100–101

Topic 4.3: Halogen derivatives	234–247	102–106
Sub-topic 4.3.1: Halogenoalkanes	235–240	102–104
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Know the chemistry of halogenoalkanes including the mechanisms of nucleophilic substitution <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Interpret and use the general, structural (condensed, semi-structural and displayed) and skeletal formulae of the halogenoalkanes Recall and use systematic nomenclature to name halogenoalkanes, with chain length up to six carbon atoms, including: naming halogeno groups in alphabetical order, e.g. 1,2-dibromo, 1-chlorobutane Deduce the molecular formula of halogenoalkanes, given its structural or skeletal formula Describe the chemistry of halogenoalkanes as exemplified by: the following nucleophilic substitution reactions of bromoethane: hydrolysis, formation of nitriles, formation of primary amines by reaction with ammonia; the elimination of hydrogen bromide from 2-bromopropane 	235–240	102–104
Sub-topic 4.3.2: Relative strength of the carbon–halogen bond	241–244	104–105
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Relative strength of the carbon–halogen bond <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Interpret the different reactivities of halogenoalkanes (with particular reference to hydrolysis and to the relative strengths of the C–Hal bonds) Explain the uses of fluoroalkanes and fluorohalogenoalkanes in terms of their relative chemical inertness Recall that the use of chlorofluoroalkanes leads to depletion of the ozone layer Recall the development of replacement compounds to prevent further depletion and allows the ozone layer to repair Explain the terms <i>bond energy</i>, <i>bond length</i> and <i>bond polarity</i> and use them to compare the reactivities of covalent bonds 	241–244	104–105
Topic 4.4: Hydroxyl compounds	248–261	107–110
Sub-topic 4.4.1: Alcohols	249–258	107–110
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand the chemistry of alcohols <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Interpret and use the general, structural (condensed, semi-structural and displayed) and skeletal formulae of the alcohols (primary, secondary and tertiary) Recall and use systematic nomenclature of alcohols, with chain length up to six carbon atoms, e.g. propan-1-ol Deduce the molecular formula of alcohols (including primary, secondary and tertiary), given its structural or skeletal formula Recall the chemistry of alcohols, exemplified by ethanol, in the following reactions: combustion; substitution to give halogenoalkanes; reaction with sodium; oxidation to carbonyl compounds and carboxylic acids; dehydration to alkenes; formation of esters by esterification with carboxylic acids classify hydroxy compounds into primary, secondary and tertiary alcohols Suggest characteristic distinguishing reactions, e.g. mild oxidation Deduce the presence of a $\text{CH}_3\text{CH}(\text{OH})-$ group in an alcohol from its reaction with alkaline aqueous iodine to form tri-iodomethane Explain why alcohols are used as solvents, including their use in cosmetics and to remove sulfur compounds from coal 	249–258	107–110

Topic 4.5: Isomerism	262–273	111–114
Sub-topic 4.5.1: Isomerism: structural and stereoisomerism	263–270	111–114
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand structural and stereoisomerism <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Deduce (draw and name) the possible isomers for an organic molecule of known molecular formula Describe structural isomerism and its division into chain, positional and functional group isomerism Describe stereoisomerism and its division into geometrical (cis-trans) and optical isomerism (use of E, Z nomenclature is acceptable but is not required) Describe geometrical (cis-trans) isomerism in alkenes, and explain its origin in terms of restricted rotation due to the presence of double bonds Explain what is meant by a chiral centre and that such a centre normally gives rise to optical isomerism (NB: Learners should appreciate that compounds can contain more than one chiral centre, but knowledge of meso compounds, or nomenclature such as <i>diastereoisomers</i> is <i>not</i> required) Identify chiral centres and geometrical (cis-trans) isomerism in a molecule of given structural formula 	263–270	111–114
Topic 4.6: Carbonyl compounds	274–283	115–117
Sub-topic 4.6.1: Aldehydes and ketones	275–281	115–117
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand the chemistry of aldehydes and ketones <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Interpret and use the general, structural (condensed, semi-structural and displayed) and skeletal formulae of the aldehydes and ketones Recall and use systematic nomenclature of aldehydes and ketones with chain length up to six carbon atoms, e.g. pentan-2-one Deduce the molecular formula of aldehydes and ketones, given their structural or skeletal formula Describe the formation of aldehydes and ketones from primary and secondary alcohols respectively using $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ 	275–281	115–117
Topic 4.7: Carboxylic acids and derivatives	284–293	118–120
Sub-topic 4.7.1: Carboxylic acids	285–287	118–119
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand the chemistry of carboxylic acids <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Interpret and use the general, structural (condensed, semi-structural and, displayed) and skeletal formulae of the carboxylic acids Recall and use systematic nomenclature of carboxylic acids chain length up to six carbon atoms, e.g. butanoic acid Deduce the molecular formula of carboxylic acids, given its structural or skeletal formula Describe the formation of carboxylic acids from alcohols and aldehydes Describe the reactions of carboxylic acids in the formation of: salts, by the use of reactive metals, alkalis or carbonates; alkyl esters 	285–287	118–119
Sub-topic 4.7.2: Esters and amines	288–291	119–120
<p><i>General objective:</i></p> <ul style="list-style-type: none"> Understand the chemistry of esters and amines <p><i>Specific objectives:</i></p> <ul style="list-style-type: none"> Interpret and use the general, structural (condensed, semi-structural and, displayed) and skeletal formulae of the carboxylic acids Recall and use systematic nomenclature of esters and amines, with chain length up to six carbon atoms, including: <ul style="list-style-type: none"> using the parent alcohol and carboxylic acid to name esters e.g. methyl ethanoate. naming amines, e.g. 2-aminobutane Deduce the molecular formula of esters and amines (primary only) given their structural or skeletal formula Describe the acid and base hydrolysis of esters and draw the structure of the hydrolysis of the products of any ester given Explain why esters are used as solvents, perfumes, flavourings 	288–291	119–120