1. Atomic structure

Weeks 1–2

原子结构

They should be able to

1. understand that atoms are mostly empty space surrounding a very small, dense **nucleus** that contains **protons** and **neutrons**; **electrons** are found in **shells** in the empty space around the nucleus
2. identify and describe protons, neutrons and electrons in terms of their relative charges and relative masses
3. understand the terms **atomic and proton number**; **mass and nucleon number**
4. describe the distribution of mass and charge within an atom
5. describe the behaviour of beams of protons, neutrons and electrons moving at the same velocity in an electric field
6. determine the numbers of protons, neutrons and electrons present in both atoms and ions given atomic or proton number, mass or nucleon number and charge
7. state and explain qualitatively the variations in **atomic radius** and **ionic radius** across a period and down a group
8. define the term **isotope** in terms of numbers of protons and neutrons
9. understand the notation ${}^{x}_{y}\mathrm{A}$ for isotopes, where x is the mass or nucleon number and y is the atomic or proton number
10. state that and explain why isotopes of the same element have the same chemical properties
11. state that and explain why isotopes of the same element have different physical properties, limited to mass and density
12. understand the terms: **shells**, **sub-shells** and **orbitals**; **principal quantum number** (n); **ground state**, limited to electronic configuration
13. describe 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
14. describe the order of increasing energy of the sub-shells within the first three shells and the 4s and 4p sub-shells
15. describe the **electronic configurations** to include the number of electrons in each shell, sub-shell and orbital
16. explain the electronic configurations in terms of energy of the electrons and inter-electron repulsion
17. determine the electronic configuration of atoms and ions given the atomic or proton number and charge, using either of the following conventions: e.g. for Fe: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$ (full electronic configuration) or [Ar] $3d^6 4s^2$ (shorthand electronic configuration)
18. understand and use the electrons in boxes notation
19. describe and sketch the shapes of s and p orbitals
20. describe a **free radical** as a species with one or more unpaired electrons
21. define and use the term **first ionisation energy**, IE
22. construct equations to represent first, second and subsequent ionisation energies
23. identify and explain the trends in ionisation energies across a period and down a group of the Periodic Table
24. identify and explain the variation in successive ionisation energies of an element
25. understand that ionisation energies are due to the attraction between the nucleus and the outer electron
26. explain the factors influencing the ionisation energies of elements in terms of **nuclear charge**, atomic/ionic radius, **shielding** by inner shells and sub-shells and **spin-pair repulsion**
27. deduce the electronic configurations of elements using successive ionisation energy data
28. deduce the position of an element in the Periodic Table using successive ionisation energy data

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Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 01 (10 questions, answers on sheet 2) Starter quiz 1 – past-paper questions	
Teach the new content	Handout 01 Slide deck 01 Vocabulary list 01	
Practice guided then independent	Exercise sheets 1.1, 1.2, 1.3, 1.4 Past-paper sheets 1.1, 1.2, 1.3, 1.4	
Check before they leave	Unit test 1 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

2. Atoms, molecules and stoichiometry

Weeks 3–4

原子、分子与化学计量

They should be able to

1. define the **unified atomic mass unit** as one twelfth of the mass of a **carbon-12** atom
2. define **relative atomic mass**, A_r, **relative isotopic mass**, **relative molecular mass**, M_r, and **relative formula mass** in terms of the unified atomic mass unit
3. define and use the term **mole** in terms of the **Avogadro constant**
4. write formulas of ionic compounds from ionic charges and oxidation numbers (shown by a Roman numeral), including: (a) the prediction of ionic charge from the position of an element in the Periodic Table (b) recall of the names and formulas for the following ions: NO_3^-, CO_3^{2-}, SO_4^{2-}, OH^-, NH_4^+, Zn^{2+}, Ag^+, HCO_3^-, PO_4^{3-}
5. (a) write and construct equations (which should be balanced), including ionic equations (which should not include spectator ions) (b) use appropriate state symbols in equations
6. define and use the terms **empirical and molecular formula**
7. understand and use the terms **anhydrous**, **hydrated** and **water of crystallisation**
8. calculate empirical and molecular formulas, using given data
9. perform calculations including use of the mole concept, involving: (a) reacting masses (from formulas and equations) including percentage yield calculations (b) volumes of gases (e.g. in the burning of hydrocarbons) (c) volumes and concentrations of solutions (d) **limiting reagent** and **excess reagent** (When performing calculations, candidates' answers should reflect the number of significant figures given or asked for in the question. When rounding up or down, candidates should ensure that significant figures are neither lost unnecessarily nor used beyond what is justified (see also Mathematical requirements section).) (e) deduce **stoichiometric** relationships from calculations such as those in 2.4.1(a)–(d)

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 02 (10 questions, answers on sheet 2) Starter quiz 2 – past-paper questions	
Teach the new content	Handout 02 Slide deck 02 Vocabulary list 02	
Practice guided then independent	Exercise sheets 2.1, 2.2, 2.3, 2.4 Past-paper sheets 2.1, 2.2, 2.3, 2.4	
Check before they leave	Unit test 2 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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3. Chemical bonding

Weeks 5–6

化学键

They should be able to

1. define **electronegativity** as the power of an atom to attract electrons to itself
2. explain the factors influencing the electronegativities of the elements in terms of nuclear charge, atomic radius and shielding by inner shells and sub-shells
3. state and explain the trends in electronegativity across a period and down a group of the Periodic Table
4. use the differences in **Pauling electronegativity** values to predict the formation of **ionic** and **covalent bonds** (the presence of covalent character in some ionic compounds will not be assessed) (Pauling electronegativity values will be given where necessary)
5. define **ionic bonding** as the electrostatic attraction between oppositely charged ions (positively charged **cations** and negatively charged **anions**)
6. describe ionic bonding including the examples of sodium chloride, magnesium oxide and calcium fluoride
7. define **metallic bonding** as the electrostatic attraction between positive metal ions and **delocalised electrons**
8. define **covalent bonding** as electrostatic attraction between the nuclei of two atoms and a shared pair of electrons (a) describe covalent bonding in molecules including: • hydrogen, H_2 • oxygen, O_2 • nitrogen, N_2 • chlorine, Cl_2 • hydrogen chloride, HCl • carbon dioxide, CO_2 • ammonia, NH_3 • methane, CH_4 • ethane, C_2H_6 • ethene, C_2H_4 (b) understand that elements in period 3 can expand their octet including in the compounds sulfur dioxide, SO_2, phosphorus pentachloride, PCl_5, and sulfur hexafluoride, SF_6 (c) describe coordinate (dative covalent) bonding, including in the reaction between ammonia and hydrogen chloride gases to form the ammonium ion, NH_4^+, and in the Al_2Cl_6 molecule
9. (a) describe covalent bonds in terms of orbital overlap giving σ and π bonds: • σ bonds are formed by direct overlap of orbitals between the bonding atoms • π bonds are formed by the sideways overlap of adjacent p orbitals above and below the σ bond (b) describe how the σ and π bonds form in molecules including H_2, C_2H_6, C_2H_4, HCN and N_2 (c) use the concept of **hybridisation** to describe sp, sp^2 and sp^3 orbitals
10. (a) define the terms: • **bond energy** as the energy required to break one mole of a particular covalent bond in the gaseous state • **bond length** as the internuclear distance of two covalently bonded atoms (b) use bond energy values and the concept of bond length to compare the reactivity of covalent molecules
11. state and explain the shapes of, and bond angles in, molecules by using **VSEPR theory**, including as simple examples: • BF_3 (trigonal planar, 120°) • CO_2 (linear, 180°) • CH_4 (tetrahedral, 109.5°) • NH_3 (pyramidal, 107°) • H_2O (non-linear, 104.5°) • SF_6 (octahedral, 90°) • PF_5 (trigonal bipyramidal, 120° and 90°)
12. predict the shapes of, and bond angles in, molecules and ions analogous to those specified in 3.5.1
13. (a) describe **hydrogen bonding**, limited to molecules containing N–H and O–H groups, including ammonia and water as simple examples (b) use the concept of hydrogen bonding to explain the anomalous properties of H_2O (ice and water): • its relatively high melting and boiling points • its relatively high surface tension • the density of the solid ice compared with the liquid water
14. use the concept of electronegativity to explain **bond polarity** and **dipole moments** of molecules
15. (a) describe **van der Waals' forces** as the intermolecular forces between molecular entities other than those due to bond formation, and use the term van der Waals' forces as a generic term to describe all intermolecular forces (b) describe the types of van der Waals' forces: • instantaneous dipole–induced dipole (id-id) forces, also called **London dispersion forces** • permanent dipole–permanent dipole (pd-pd) forces, including hydrogen bonding (c) describe hydrogen bonding and understand that hydrogen bonding is a special case of permanent dipole–permanent dipole forces between molecules where hydrogen is bonded to a highly electronegative atom
16. state that, in general, ionic, covalent and metallic bonding are stronger than intermolecular forces
17. use **dot-and-cross diagrams** to illustrate ionic, covalent and coordinate bonding including the representation of any compounds stated in 3.4 and 3.5 (dot-and-cross diagrams may include species with atoms which have an expanded octet or species with an odd number of electrons)

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 03 (10 questions, answers on sheet 2) Starter quiz 3 – past-paper questions	
Teach the new content	Handout 03 Slide deck 03 Vocabulary list 03	
Practice guided then independent	Exercise sheets 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7 Past-paper sheets 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7	
Check before they leave	Unit test 3 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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4. States of matter

Weeks 7

物质的状态

They should be able to

1. explain the origin of **pressure** in a gas in terms of collisions between gas molecules and the wall of the container
2. understand that **ideal gases** have zero particle volume and no **intermolecular forces** of attraction
3. state and use the **ideal gas equation** $pV = nRT$ in calculations, including in the determination of M_r
4. describe, in simple terms, the **lattice structure** of a **crystalline solid** which is: (a) giant ionic, including sodium chloride and magnesium oxide (b) simple molecular, including iodine, buckminsterfullerene C_{60} and ice (c) giant molecular, including silicon(IV) oxide, graphite and diamond (d) giant metallic, including copper
5. describe, interpret and predict the effect of different types of structure and bonding on the physical properties of substances, including **melting point**, **boiling point**, **electrical conductivity** and **solubility**
6. deduce the type of structure and bonding present in a substance from given information

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 04 (10 questions, answers on sheet 2)	
Teach the new content	Handout 04 Slide deck 04 Vocabulary list 04	
Practice guided then independent	Exercise sheets 4.1, 4.2 Past-paper sheets 4.1, 4.2	
Check before they leave	Unit test 4 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

5. Chemical energetics

Weeks 8–9

化学能量学

They should be able to

1. understand that chemical reactions are accompanied by **enthalpy changes** and these changes can be **exothermic** (ΔH is negative) or **endothermic** (ΔH is positive)
2. construct and interpret a **reaction pathway diagram**, in terms of the enthalpy change of the reaction and of the **activation energy**
3. define and use the terms: (a) **standard conditions** (this syllabus assumes that these are 298 K and 101 kPa) shown by $^{\ominus}$. (b) enthalpy change with particular reference to: reaction, ΔH_r, formation, ΔH_f, combustion, ΔH_c, neutralisation, ΔH_{neut}
4. understand that energy transfers occur during chemical reactions because of the breaking and making of chemical bonds
5. use bond energies (ΔH positive, i.e. bond breaking) to calculate enthalpy change of reaction, ΔH_r
6. understand that some bond energies are exact and some bond energies are averages
7. calculate enthalpy changes from appropriate experimental results, including the use of the relationships $q = mc\Delta T$ and $\Delta H = -mc\Delta T/n$
8. apply **Hess's law** to construct simple energy cycles
9. carry out calculations using cycles and relevant energy terms, including: (a) determining enthalpy changes that cannot be found by direct experiment (b) use of bond energy data

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 05 (10 questions, answers on sheet 2) Starter quiz 5 – past-paper questions	
Teach the new content	Handout 05 Slide deck 05 Vocabulary list 05	
Practice guided then independent	Exercise sheets 5.1, 5.2 Past-paper sheets 5.1, 5.2	
Check before they leave	Unit test 5 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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6. Electrochemistry

Weeks 10

电化学

They should be able to

1. calculate **oxidation numbers** of elements in compounds and ions
2. use changes in oxidation numbers to help balance chemical equations
3. explain and use the terms **redox**, **oxidation**, **reduction** and **disproportionation** in terms of electron transfer and changes in oxidation number
4. explain and use the terms **oxidising agent** and **reducing agent**
5. use a Roman numeral to indicate the magnitude of the oxidation number of an element

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 06 (10 questions, answers on sheet 2) Starter quiz 6 – past-paper questions	
Teach the new content	Handout 06 Slide deck 06 Vocabulary list 06	
Practice guided then independent	Exercise sheets 6.1 Past-paper sheets 6.1	
Check before they leave	Unit test 6 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

7. Equilibria

Weeks 11–12

平衡

They should be able to

1. (a) understand what is meant by a **reversible reaction** (b) understand what is meant by **dynamic equilibrium** in terms of the rate of forward and reverse reactions being equal and the concentration of reactants and products remaining constant (c) understand the need for a closed system in order to establish dynamic equilibrium
2. define **Le Chatelier's principle** as: if a change is made to a system at dynamic equilibrium, the position of equilibrium moves to minimise this change
3. use Le Chatelier's principle to deduce qualitatively (from appropriate information) the effects of changes in temperature, concentration, pressure or presence of a catalyst on a system at equilibrium
4. deduce expressions for **equilibrium constants** in terms of concentrations, K_c
5. use the terms **mole fraction** and **partial pressure**
6. deduce expressions for equilibrium constants in terms of partial pressures, K_p (use of the relationship between K_p and K_c is not required)
7. use the K_c and K_p expressions to carry out calculations (such calculations will not require the solving of quadratic equations)
8. calculate the quantities present at equilibrium, given appropriate data
9. state whether changes in temperature, concentration or pressure or the presence of a catalyst affect the value of the equilibrium constant for a reaction
10. describe and explain the conditions used in the **Haber process** and the **Contact process**, as examples of the importance of an understanding of dynamic equilibrium in the chemical industry and the application of Le Chatelier's principle
11. state the names and formulas of the common acids, limited to **hydrochloric acid**, HCl, **sulfuric acid**, H_2SO_4, **nitric acid**, HNO_3, **ethanoic acid**, CH_3COOH
12. state the names and formulas of the common alkalis, limited to **sodium hydroxide**, NaOH, **potassium hydroxide**, KOH, **ammonia**, NH_3
13. describe the **Brønsted–Lowry theory** of acids and bases
14. describe **strong acids** and **strong bases** as **fully dissociated** in aqueous solution and **weak acids** and **weak bases** as **partially dissociated** in aqueous solution
15. appreciate that water has pH of 7, acid solutions pH of below 7 and alkaline solutions pH of above 7
16. explain qualitatively the differences in behaviour between strong and weak acids including the reaction with a reactive metal and difference in pH values by use of a pH meter, universal indicator or conductivity
17. understand that neutralisation reactions occur when $H^+(aq)$ and $OH^-(aq)$ form $H_2O(l)$
18. understand that salts are formed in neutralisation reactions
19. sketch the **pH titration curves** of titrations using combinations of strong and weak acids with strong and weak alkalis
20. select suitable indicators for acid-alkali titrations, given appropriate data (pK_a values will not be used)

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 07 (10 questions, answers on sheet 2) Starter quiz 7 – past-paper questions	
Teach the new content	Handout 07 Slide deck 07 Vocabulary list 07	
Practice guided then independent	Exercise sheets 7.1, 7.2 Past-paper sheets 7.1, 7.2	
Check before they leave	Unit test 7 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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8. Reaction kinetics

Weeks 13

反应动力学

They should be able to

1. explain and use the term **rate of reaction**, **frequency of collisions**, **effective collisions** and non-effective collisions
2. explain qualitatively, in terms of frequency of effective collisions, the effect of concentration and pressure changes on the rate of a reaction
3. use experimental data to calculate the rate of a reaction
4. define **activation energy**, E_A, as the minimum energy required for a collision to be effective
5. sketch and use the **Boltzmann distribution** to explain the significance of activation energy
6. explain qualitatively, in terms both of the Boltzmann distribution and of frequency of effective collisions, the effect of temperature change on the rate of a reaction
7. explain and use the terms **catalyst** and **catalysis**: (a) explain that, in the presence of a catalyst, a reaction has a different mechanism, i.e. one of lower activation energy (b) explain this catalytic effect in terms of the Boltzmann distribution (c) construct and interpret a reaction pathway diagram, for a reaction in the presence and absence of an effective catalyst

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 08 (10 questions, answers on sheet 2) Starter quiz 8 – past-paper questions	
Teach the new content	Handout 08 Slide deck 08 Vocabulary list 08	
Practice guided then independent	Exercise sheets 8.1, 8.2, 8.3 Past-paper sheets 8.1, 8.2, 8.3	
Check before they leave	Unit test 8 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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9. The Periodic Table: chemical periodicity

Weeks 14–15

元素周期表：化学周期性

They should be able to

1. describe qualitatively (and indicate the periodicity in) the variations in **atomic radius**, **ionic radius**, **melting point** and **electrical conductivity** of the elements
2. explain the variation in melting point and electrical conductivity in terms of the structure and bonding of the elements
3. describe, and write equations for, the reactions of the elements with oxygen (to give Na_2O, MgO, Al_2O_3, P_4O_{10}, SO_2), chlorine (to give NaCl, $MgCl_2$, $AlCl_3$, $SiCl_4$, PCl_5) and water (Na and Mg only)
4. state and explain the variation in the **oxidation number** of the oxides (Na_2O, MgO, Al_2O_3, P_4O_{10}, SO_2 and SO_3 only) and chlorides (NaCl, $MgCl_2$, $AlCl_3$, $SiCl_4$, PCl_5 only) in terms of their outer shell (valence shell) electrons
5. describe, and write equations for, the reactions, if any, of the oxides Na_2O, MgO, Al_2O_3, SiO_2, P_4O_{10}, SO_2 and SO_3 with water including the likely pHs of the solutions obtained
6. describe, explain, and write equations for, the acid/base behaviour of the oxides Na_2O, MgO, Al_2O_3, P_4O_{10}, SO_2 and SO_3 and the hydroxides NaOH, $Mg(OH)_2$ and $Al(OH)_3$ including, where relevant, amphoteric behaviour in reactions with acids and bases (sodium hydroxide only)
7. describe, explain, and write equations for, the reactions of the chlorides NaCl, $MgCl_2$, $AlCl_3$, $SiCl_4$, PCl_5 with water including the likely pHs of the solutions obtained
8. explain the variations and trends in 9.2.2, 9.2.3, 9.2.4 and 9.2.5 in terms of bonding and electronegativity
9. suggest the types of chemical bonding present in the chlorides and oxides from observations of their chemical and physical properties
10. predict the characteristic properties of an element in a given group by using knowledge of **chemical periodicity**
11. deduce the nature, possible position in the Periodic Table and identity of unknown elements from given information about physical and chemical properties

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 09 (10 questions, answers on sheet 2) Starter quiz 9 – past-paper questions	
Teach the new content	Handout 09 Slide deck 09 Vocabulary list 09	
Practice guided then independent	Exercise sheets 9.1, 9.2, 9.3 Past-paper sheets 9.1, 9.2, 9.3	
Check before they leave	Unit test 9 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

10. Group 2

Weeks 16

第 2 族

They should be able to

1. describe, and write equations for, the reactions of the elements with oxygen, water and dilute hydrochloric and sulfuric acids
2. describe, and write equations for, the reactions of the oxides, hydroxides and carbonates with water and dilute hydrochloric and sulfuric acids
3. describe, and write equations for, the **thermal decomposition** of the nitrates and carbonates, to include the trend in **thermal stabilities**
4. describe, and make predictions from, the trends in physical and chemical properties of the elements involved in the reactions in 10.1.1 and the compounds involved in 10.1.2, 10.1.3 and 10.1.5
5. state the variation in the **solubilities** of the hydroxides and sulfates

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 10 (10 questions, answers on sheet 2) Starter quiz 10 – past-paper questions	
Teach the new content	Handout 10 Slide deck 10 Vocabulary list 10	
Practice guided then independent	Exercise sheets 10.1 Past-paper sheets 10.1	
Check before they leave	Unit test 10 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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11. Group 17

Weeks 17–18

第 17 族

They should be able to

1. describe the colours and the trend in **volatility** of chlorine, bromine and iodine
2. describe and explain the trend in the **bond strength** of the halogen molecules
3. interpret the volatility of the elements in terms of instantaneous dipole–induced dipole forces
4. describe the relative reactivity of the elements as **oxidising agents**
5. describe the reactions of the elements with hydrogen and explain their relative reactivity in these reactions
6. describe the relative **thermal stabilities** of the **hydrogen halides** and explain these in terms of bond strengths
7. describe the relative reactivity of halide ions as **reducing agents**
8. describe and explain the reactions of halide ions with: (a) aqueous silver ions followed by aqueous ammonia (the formation and formula of the $[Ag(NH_3)_2]^+$ complex is not required) (b) concentrated sulfuric acid, to include balanced chemical equations
9. describe and interpret, in terms of changes in oxidation number, the reaction of chlorine with cold and with hot aqueous sodium hydroxide and recognise these as **disproportionation reactions**
10. explain, including by use of an equation, the use of chlorine in **water purification** to include the production of the active species HOCl and ClO^- which kill bacteria

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 11 (10 questions, answers on sheet 2) Starter quiz 11 – past-paper questions	
Teach the new content	Handout 11 Slide deck 11 Vocabulary list 11	
Practice guided then independent	Exercise sheets 11.1, 11.2, 11.3, 11.4 Past-paper sheets 11.1, 11.2, 11.3, 11.4	
Check before they leave	Unit test 11 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

12. Nitrogen and sulfur

Weeks 19

氮与硫

They should be able to

1. explain the lack of reactivity of nitrogen, with reference to **triple bond** strength and lack of polarity
2. describe and explain: (a) the **basicity** of ammonia, using the **Brønsted–Lowry theory** (b) the structure of the ammonium ion and its formation by an acid–base reaction (c) the displacement of ammonia from ammonium salts by an acid–base reaction
3. state and explain the natural and man-made occurrences of oxides of nitrogen and their catalytic removal from the exhaust gases of internal combustion engines
4. understand that atmospheric oxides of nitrogen (NO and NO_2) can react with unburned hydrocarbons to form **peroxyacetyl nitrate**, PAN, which is a component of **photochemical smog**
5. describe the role of NO and NO_2 in the formation of **acid rain** both directly and in their catalytic role in the oxidation of atmospheric sulfur dioxide

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 12 (10 questions, answers on sheet 2)	
Teach the new content	Handout 12 Slide deck 12 Vocabulary list 12	
Practice guided then independent	Exercise sheets 12.1 Past-paper sheets 12.1	
Check before they leave	Unit test 12 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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13. An introduction to AS Level organic chemistry

Weeks 20–21

AS Level 有机化学导论

They should be able to

1. define the term **hydrocarbon** as a compound made up of C and H atoms only
2. understand that **alkanes** are simple hydrocarbons with no **functional group**
3. understand that the compounds in the table on pages 29 and 30 contain a functional group which dictates their physical and chemical properties
4. interpret and use the general, structural, displayed and skeletal formulas of the classes of compound stated in the table on pages 29 and 30
5. understand and use **systematic nomenclature** of simple aliphatic organic molecules with functional groups detailed in the table on pages 29 and 30, up to six carbon atoms (six plus six for esters, straight chains only for esters and nitriles)
6. deduce the molecular and/or empirical formula of a compound, given its structural, displayed or skeletal formula
7. interpret and use the following terminology associated with types of organic compounds and reactions: (a) **homologous series** (b) **saturated and unsaturated** (c) **homolytic and heterolytic fission** (d) free radical, initiation, propagation, termination (e) **nucleophile**, **electrophile**, nucleophilic, electrophilic (f) **addition**, **substitution**, **elimination**, **hydrolysis**, **condensation** (g) oxidation and reduction (in equations for organic redox reactions, the symbol [O] can be used to represent one atom of oxygen from an oxidising agent and the symbol [H] to represent one atom of hydrogen from a reducing agent)
8. understand and use the following terminology associated with types of organic mechanisms: (a) **free-radical substitution** (b) **electrophilic addition** (c) **nucleophilic substitution** (d) **nucleophilic addition** (in organic reaction mechanisms, the use of curly arrows to represent movement of electron pairs is expected; the arrow should begin at a bond or a lone pair of electrons)
9. describe organic molecules as either **straight-chained**, **branched** or **cyclic**
10. describe and explain the shape of, and bond angles in, molecules containing sp, sp^2 and sp^3 hybridised atoms
11. describe the arrangement of σ and π bonds in molecules containing sp, sp^2 and sp^3 hybridised atoms
12. understand and use the term **planar** when describing the arrangement of atoms in organic molecules, for example ethene
13. describe **structural isomerism** and its division into **chain**, **positional** and **functional group isomerism**
14. describe **stereoisomerism** and its division into **geometrical (cis/trans)** and **optical isomerism** (use of E/Z nomenclature is acceptable but is not required)
15. describe geometrical (cis/trans) isomerism in alkenes, and explain its origin in terms of restricted rotation due to the presence of π bonds
16. explain what is meant by a **chiral centre** and that such a centre gives rise to two optical isomers (**enantiomers**) (Candidates should appreciate that compounds can contain more than one chiral centre, but knowledge of meso compounds, or nomenclature such as diastereoisomers is not required.)
17. identify chiral centres and geometrical (cis/trans) isomerism in a molecule of given structural formula including cyclic compounds
18. deduce the possible isomers for an organic molecule of known molecular formula

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 13 (10 questions, answers on sheet 2) Starter quiz 13 – past-paper questions	
Teach the new content	Handout 13 Slide deck 13 Vocabulary list 13	

Stage	Use	Your notes
Practice guided then independent	Exercise sheets 13.1, 13.2, 13.3, 13.4 Past-paper sheets 13.1, 13.2, 13.3, 13.4	
Check before they leave	Unit test 13 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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14. Hydrocarbons

Weeks 22–23

烃

They should be able to

1. recall the reactions (reagents and conditions) by which alkanes can be produced: (a) addition of hydrogen to an alkene in a hydrogenation reaction, $H_2(g)$ and Pt/Ni catalyst and heat (b) cracking of a longer chain alkane, heat with Al_2O_3
2. describe: (a) the complete and incomplete combustion of alkanes (b) the free-radical substitution of alkanes by Cl_2 or Br_2 in the presence of ultraviolet light, as exemplified by the reactions of ethane
3. describe the mechanism of **free-radical substitution** with reference to the **initiation**, **propagation** and **termination** steps
4. suggest how cracking can be used to obtain more useful alkanes and alkenes of lower M_r from heavier crude oil fractions
5. understand the general unreactivity of alkanes, including towards polar reagents in terms of the strength of the C–H bonds and their relative lack of polarity
6. recognise the environmental consequences of **carbon monoxide**, oxides of nitrogen and unburnt hydrocarbons arising from the combustion of alkanes in the internal combustion engine and of their catalytic removal
7. recall the reactions (including reagents and conditions) by which alkenes can be produced: (a) elimination of HX from a halogenoalkane by ethanolic NaOH and heat (b) dehydration of an alcohol, by using a heated catalyst (e.g. Al_2O_3) or a concentrated acid (e.g. concentrated H_2SO_4) (c) cracking of a longer chain alkane
8. describe the following reactions of alkenes: (a) the electrophilic addition of (i) hydrogen in a hydrogenation reaction, $H_2(g)$ and Pt/Ni catalyst and heat (ii) steam, $H_2O(g)$ and H_3PO_4 catalyst (iii) a hydrogen halide, HX(g), at room temperature (iv) a halogen, X_2 (b) the oxidation by cold dilute acidified $KMnO_4$ to form the diol (c) the oxidation by hot concentrated acidified $KMnO_4$ leading to the rupture of the carbon–carbon double bond and the identities of the subsequent products to determine the position of alkene linkages in larger molecules (d) addition polymerisation exemplified by the reactions of ethene and propene
9. describe the use of aqueous bromine to show the presence of a C=C bond
10. describe the mechanism of **electrophilic addition** in alkenes, using bromine/ethene and hydrogen bromide/propene as examples
11. describe and explain the inductive effects of alkyl groups on the stability of **primary**, **secondary** and **tertiary cations** formed during electrophilic addition (this should be used to explain **Markovnikov addition**)

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 14 (10 questions, answers on sheet 2) Starter quiz 14 – past-paper questions	
Teach the new content	Handout 14 Slide deck 14 Vocabulary list 14	
Practice guided then independent	Exercise sheets 14.1, 14.2 Past-paper sheets 14.1, 14.2	
Check before they leave	Unit test 14 (with mark scheme)	

Stage	Use	Your notes
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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15. Halogen compounds

Weeks 24

卤素化合物

They should be able to

1. recall the reactions (reagents and conditions) by which halogenoalkanes can be produced: (a) the free-radical substitution of alkanes by Cl_2 or Br_2 in the presence of ultraviolet light, as exemplified by the reactions of ethane (b) electrophilic addition of an alkene with a halogen, X_2, or hydrogen halide, HX(g), at room temperature (c) substitution of an alcohol, e.g. by reaction with HX(g); or with KCl and concentrated H_2SO_4 or concentrated H_3PO_4; or with PCl_3 and heat; or with PCl_5; or with $SOCl_2$
2. classify halogenoalkanes into **primary**, **secondary** and **tertiary**
3. describe the following **nucleophilic substitution** reactions: (a) the reaction with NaOH(aq) and heat to produce an alcohol (b) the reaction with KCN in ethanol and heat to produce a nitrile (c) the reaction with NH_3 in ethanol heated under pressure to produce an amine (d) the reaction with aqueous silver nitrate in ethanol as a method of identifying the halogen present as exemplified by bromoethane
4. describe the **elimination reaction** with NaOH in ethanol and heat to produce an alkene as exemplified by bromoethane
5. describe the S_N1 and S_N2 mechanisms of nucleophilic substitution in halogenoalkanes including the inductive effects of alkyl groups
6. recall that primary halogenoalkanes tend to react via the S_N2 mechanism; tertiary halogenoalkanes via the S_N1 mechanism; and secondary halogenoalkanes by a mixture of the two, depending on structure
7. describe and explain the different reactivities of halogenoalkanes (with particular reference to the relative strengths of the C–X bonds as exemplified by the reactions of halogenoalkanes with aqueous silver nitrates)

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 15 (10 questions, answers on sheet 2) Starter quiz 15 – past-paper questions	
Teach the new content	Handout 15 Slide deck 15 Vocabulary list 15	
Practice guided then independent	Exercise sheets 15.1 Past-paper sheets 15.1	
Check before they leave	Unit test 15 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

16. Hydroxy compounds

Weeks 25

羟基化合物

They should be able to

1. recall the reactions (reagents and conditions) by which alcohols can be produced: (a) electrophilic addition of steam to an alkene, $H_2O(g)$ and H_3PO_4 catalyst (b) reaction of alkenes with cold dilute acidified potassium manganate(VII) to form a diol (c) substitution of a halogenoalkane using NaOH(aq) and heat (d) reduction of an aldehyde or ketone using $NaBH_4$ or $LiAlH_4$ (e) reduction of a carboxylic acid using $LiAlH_4$ (f) hydrolysis of an ester using dilute acid or dilute alkali and heat
2. describe: (a) the reaction with oxygen (combustion) (b) substitution to form halogenoalkanes, e.g. by reaction with HX(g); or with KCl and concentrated H_2SO_4 or concentrated H_3PO_4; or with PCl_3 and heat; or with PCl_5; or with $SOCl_2$ (c) the reaction with Na(s) (d) oxidation with acidified $K_2Cr_2O_7$ or acidified $KMnO_4$ to: (i) carbonyl compounds by distillation (ii) carboxylic acids by refluxing (primary alcohols give aldehydes which can be further oxidised to carboxylic acids, secondary alcohols give ketones, tertiary alcohols cannot be oxidised) (e) dehydration to an alkene, by using a heated catalyst, e.g. Al_2O_3 or a concentrated acid (f) formation of esters by reaction with carboxylic acids and concentrated H_2SO_4 as catalyst as exemplified by ethanol
3. (a) classify alcohols as **primary**, **secondary** and **tertiary alcohols**, to include examples with more than one alcohol group (b) state characteristic distinguishing reactions, e.g. mild oxidation with acidified $K_2Cr_2O_7$, colour change from orange to green
4. deduce the presence of a $CH_3CH(OH)-$ group in an alcohol, $CH_3CH(OH)-R$, from its reaction with alkaline $I_2(aq)$ to form a yellow precipitate of tri-iodomethane and an ion, RCO_2^-
5. explain the **acidity** of alcohols compared with water

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 16 (10 questions, answers on sheet 2) Starter quiz 16 – past-paper questions	
Teach the new content	Handout 16 Slide deck 16 Vocabulary list 16	
Practice guided then independent	Exercise sheets 16.1 Past-paper sheets 16.1	
Check before they leave	Unit test 16 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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17. Carbonyl compounds

Weeks 26

羰基化合物

They should be able to

1. recall the reactions (reagents and conditions) by which aldehydes and ketones can be produced: (a) the oxidation of primary alcohols using acidified $K_2Cr_2O_7$ or acidified $KMnO_4$ and distillation to produce aldehydes (b) the oxidation of secondary alcohols using acidified $K_2Cr_2O_7$ or acidified $KMnO_4$ and distillation to produce ketones
2. describe: (a) the reduction of aldehydes and ketones using $NaBH_4$ or $LiAlH_4$ to produce alcohols (b) the reaction of aldehydes and ketones with HCN, KCN as catalyst, and heat to produce hydroxynitriles as exemplified by ethanal and propanone
3. describe the mechanism of the **nucleophilic addition** reactions of hydrogen cyanide with aldehydes and ketones in 17.1.2(b)
4. describe the use of **2,4-dinitrophenylhydrazine (2,4-DNPH reagent)** to detect the presence of carbonyl compounds
5. deduce the nature (aldehyde or ketone) of an unknown carbonyl compound from the results of simple tests (Fehling's and Tollens' reagents; ease of oxidation)
6. deduce the presence of a CH_3CO- group in an aldehyde or ketone, CH_3CO-R, from its reaction with alkaline $I_2(aq)$ to form a yellow precipitate of tri-iodomethane and an ion, RCO_2^-

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 17 (10 questions, answers on sheet 2) Starter quiz 17 – past-paper questions	
Teach the new content	Handout 17 Slide deck 17 Vocabulary list 17	
Practice guided then independent	Exercise sheets 17.1 Past-paper sheets 17.1	
Check before they leave	Unit test 17 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

18. Carboxylic acids and derivatives

Weeks 27

羧酸及其衍生物

They should be able to

1. recall the reactions by which carboxylic acids can be produced: (a) oxidation of primary alcohols and aldehydes with acidified $K_2Cr_2O_7$ or acidified $KMnO_4$ and refluxing (b) hydrolysis of nitriles with dilute acid or dilute alkali followed by acidification (c) hydrolysis of esters with dilute acid or dilute alkali and heat followed by acidification
2. describe: (a) the **redox reaction** with reactive metals to produce a salt and $H_2(g)$ (b) the **neutralisation reaction** with alkalis to produce a salt and $H_2O(l)$ (c) the acid–base reaction with carbonates to produce a salt and $H_2O(l)$ and $CO_2(g)$ (d) **esterification** with alcohols with concentrated H_2SO_4 as catalyst (e) reduction by $LiAlH_4$ to form a primary alcohol
3. recall the reaction (reagents and conditions) by which esters can be produced: (a) the **condensation reaction** between an alcohol and a carboxylic acid with concentrated H_2SO_4 as catalyst
4. describe the **hydrolysis** of esters by dilute acid and by dilute alkali and heat

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 18 (10 questions, answers on sheet 2) Starter quiz 18 – past-paper questions	
Teach the new content	Handout 18 Slide deck 18 Vocabulary list 18	
Practice guided then independent	Exercise sheets 18.1, 18.2 Past-paper sheets 18.1, 18.2	
Check before they leave	Unit test 18 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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19. Nitrogen compounds

Weeks 28

含氮化合物

They should be able to

1. recall the reactions by which **amines** can be produced: (a) reaction of a halogenoalkane with NH_3 in ethanol heated under pressure Classification of amines will not be tested at AS Level.
2. recall the reactions by which **nitriles** can be produced: (a) reaction of a halogenoalkane with KCN in ethanol and heat
3. recall the reactions by which **hydroxynitriles** can be produced: (a) the reaction of aldehydes and ketones with HCN, KCN as catalyst, and heat
4. describe the **hydrolysis** of nitriles with dilute acid or dilute alkali followed by acidification to produce a **carboxylic acid**

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 19 (10 questions, answers on sheet 2)	
Teach the new content	Handout 19 Slide deck 19 Vocabulary list 19	
Practice guided then independent	Exercise sheets 19.1, 19.2 Past-paper sheets 19.1, 19.2	
Check before they leave	Unit test 19 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

20. Polymerisation

Weeks 29

聚合

They should be able to

1. describe **addition polymerisation** as exemplified by poly(ethene) and poly(chloroethene), PVC
2. deduce the **repeat unit** of an addition polymer obtained from a given **monomer**
3. identify the monomer(s) present in a given section of an addition polymer molecule
4. recognise the difficulty of the disposal of poly(alkene)s, i.e. **non-biodegradability** and harmful combustion products

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 20 (10 questions, answers on sheet 2)	
Teach the new content	Handout 20 Slide deck 20 Vocabulary list 20	
Practice guided then independent	Exercise sheets 20.1 Past-paper sheets 20.1	
Check before they leave	Unit test 20 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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21. Organic synthesis

Weeks 30

有机合成

They should be able to

1. for an organic molecule containing several **functional groups**: (a) identify organic functional groups using the reactions in the syllabus (b) predict properties and reactions
2. devise **multi-step synthetic routes** for preparing organic molecules using the reactions in the syllabus
3. analyse a given synthetic route in terms of type of reaction and reagents used for each step of it, and possible by-products

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 21 (10 questions, answers on sheet 2)	
Teach the new content	Handout 21 Slide deck 21 Vocabulary list 21	
Practice guided then independent	Exercise sheets 21.1 Past-paper sheets 21.1	
Check before they leave	*nothing in the Library for this stage yet*	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

22. Analytical techniques

Weeks 31

分析技术

They should be able to

1. analyse an **infrared spectrum** of a simple molecule to identify **functional groups** (see the Data section for the functional groups required)
2. analyse mass spectra in terms of m/e values and **isotopic abundances** (knowledge of the working of the mass spectrometer is not required)
3. calculate the **relative atomic mass** of an element given the relative abundances of its isotopes, or its mass spectrum
4. deduce the molecular mass of an organic molecule from the **molecular ion peak** in a mass spectrum
5. suggest the identity of molecules formed by simple fragmentation in a given mass spectrum
6. deduce the number of carbon atoms, n, in a compound using the $[M + 1]^+$ peak and the formula $n = \frac{100\times\text{abundance of } [M+1]^+ \text{ ion}}{1.1\times\text{abundance of } M^+ \text{ ion}}$
7. deduce the presence of bromine and chlorine atoms in a compound using the $[M + 2]^+$ peak

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 22 (10 questions, answers on sheet 2)	
Teach the new content	Handout 22 Slide deck 22 Vocabulary list 22	
Practice guided then independent	Exercise sheets 22.1, 22.2 Past-paper sheets 22.1, 22.2	
Check before they leave	Unit test 22 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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23. Chemical energetics

Weeks 32–33

化学能量学

They should be able to

1. define and use the terms: (a) **enthalpy change of atomisation**, ΔH_{at} (b) **lattice energy**, ΔH_{latt} (the change from gas phase ions to solid lattice)
2. (a) define and use the term **first electron affinity**, EA (b) explain the factors affecting the electron affinities of elements (c) describe and explain the trends in the electron affinities of the Group 16 and Group 17 elements
3. construct and use **Born–Haber cycles** for ionic solids (limited to +1 and +2 cations, –1 and –2 anions)
4. carry out calculations involving Born–Haber cycles
5. explain, in qualitative terms, the effect of ionic charge and of ionic radius on the numerical magnitude of a lattice energy
6. define and use the term enthalpy change with reference to **hydration**, ΔH_{hyd}, and **solution**, ΔH_{sol}
7. construct and use an energy cycle involving **enthalpy change of solution**, **lattice energy** and **enthalpy change of hydration**
8. carry out calculations involving the energy cycles in 23.2.2
9. explain, in qualitative terms, the effect of ionic charge and of ionic radius on the numerical magnitude of an enthalpy change of hydration
10. define the term **entropy**, S, as the number of possible arrangements of the particles and their energy in a given system
11. predict and explain the sign of the entropy changes that occur: (a) during a change in state, e.g. melting, boiling and dissolving (and their reverse) (b) during a temperature change (c) during a reaction in which there is a change in the number of gaseous molecules
12. calculate the entropy change for a reaction, ΔS, given the standard entropies, $S^\ominus$, of the reactants and products, $\Delta S^\ominus = \Sigma S^\ominus(\text{products}) - \Sigma S^\ominus(\text{reactants})$ (use of $\Delta S^\ominus = \Delta S^\ominus_{\text{surr}} + \Delta S^\ominus_{\text{sys}}$ is not required)
13. state and use the **Gibbs equation** $\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$
14. perform calculations using the equation $\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$
15. state whether a reaction or process will be **feasible** by using the sign of ΔG
16. predict the effect of temperature change on the feasibility of a reaction, given standard enthalpy and entropy changes

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 23 (10 questions, answers on sheet 2)	
Teach the new content	Handout 23 Slide deck 23 Vocabulary list 23	
Practice guided then independent	Exercise sheets 23.1, 23.2, 23.3, 23.4 Past-paper sheets 23.1, 23.2, 23.3, 23.4	
Check before they leave	Unit test 23 (with mark scheme)	

Stage	Use	Your notes
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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24. Electrochemistry

Weeks 34–35

电化学

They should be able to

1. predict the identities of substances liberated during **electrolysis** from the state of **electrolyte** (molten or aqueous), position in the redox series (electrode potential) and concentration
2. state and apply the relationship $F = Le$ between the **Faraday constant**, F, the **Avogadro constant**, L, and the charge on the electron, e
3. calculate: (a) the quantity of charge passed during electrolysis, using $Q = It$ (b) the mass and/or volume of substance liberated during electrolysis
4. describe the determination of a value of the Avogadro constant by an electrolytic method
5. define the terms: (a) **standard electrode (reduction) potential** (b) **standard cell potential**
6. describe the **standard hydrogen electrode**
7. describe methods used to measure the standard electrode potentials of: (a) metals or non-metals in contact with their ions in aqueous solution (b) ions of the same element in different oxidation states
8. calculate a standard cell potential by combining two standard electrode potentials
9. use standard cell potentials to: (a) deduce the polarity of each electrode and hence explain/deduce the direction of electron flow in the external circuit of a simple cell (b) predict the feasibility of a reaction
10. deduce from $E^{\ominus}$ values the relative reactivity of elements, compounds and ions as oxidising agents or as reducing agents
11. construct redox equations using the relevant half-equations
12. predict qualitatively how the value of an electrode potential, E, varies with the concentrations of the aqueous ions
13. use the **Nernst equation**, e.g. $E = E^{\ominus} + (0.059/z) \log \frac{[\text{oxidised species}]}{[\text{reduced species}]}$, to predict quantitatively how the value of an electrode potential varies with the concentrations of the aqueous ions; examples include $Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$, $Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$
14. understand and use the equation $\Delta G^{\ominus} = -nE^{\ominus}_{\text{cell}}F$

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 24 (10 questions, answers on sheet 2)	
Teach the new content	Handout 24 Slide deck 24 Vocabulary list 24	
Practice guided then independent	Exercise sheets 24.1, 24.2 Past-paper sheets 24.1, 24.2	
Check before they leave	Unit test 24 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

25. Equilibria

Weeks 36–37

平衡

They should be able to

1. understand and use the terms **conjugate acid** and **conjugate base**
2. define conjugate acid–base pairs, identifying such pairs in reactions
3. define mathematically the terms pH, K_a, pK_a and K_w and use them in calculations (K_b and the equation $K_w = K_a \times K_b$ will not be tested)
4. calculate $[H^+(aq)]$ and pH values for: (a) strong acids (b) strong alkalis (c) weak acids
5. (a) define a **buffer solution** (b) explain how a buffer solution can be made (c) explain how buffer solutions control pH; use chemical equations in these explanations (d) describe and explain the uses of buffer solutions, including the role of HCO_3^- in controlling pH in blood
6. calculate the pH of buffer solutions, given appropriate data
7. understand and use the term **solubility product**, K_{sp}
8. write an expression for K_{sp}
9. calculate K_{sp} from concentrations and vice versa
10. (a) understand and use the **common ion effect** to explain the different solubility of a compound in a solution containing a common ion (b) perform calculations using K_{sp} values and concentration of a common ion
11. state what is meant by the term **partition coefficient**, K_{pc}
12. calculate and use a partition coefficient for a system in which the solute is in the same physical state in the two solvents
13. understand the factors affecting the numerical value of a partition coefficient in terms of the polarities of the solute and the solvents used

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 25 (10 questions, answers on sheet 2)	
Teach the new content	Handout 25 Slide deck 25 Vocabulary list 25	
Practice guided then independent	Exercise sheets 25.1, 25.2 Past-paper sheets 25.1, 25.2	
Check before they leave	Unit test 25 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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26. Reaction kinetics

Weeks 38–39

反应动力学

They should be able to

1. explain and use the terms **rate equation**, **order of reaction**, overall order of reaction, **rate constant**, **half-life**, **rate-determining step** and **intermediate**
2. (a) understand and use rate equations of the form rate $= k[A]^m[B]^n$ (for which m and n are 0, 1 or 2) (b) deduce the order of a reaction from concentration–time graphs or from experimental data relating to the initial rates method and half-life method (c) interpret experimental data in graphical form, including concentration–time and rate–concentration graphs (d) calculate an initial rate using concentration data (e) construct a rate equation
3. (a) show understanding that the half-life of a first-order reaction is independent of concentration (b) use the half-life of a first-order reaction in calculations
4. calculate the numerical value of a rate constant, for example by: (a) using the initial rates and the rate equation (b) using the half-life, $t_{\frac{1}{2}}$, and the equation $k = 0.693/t_{\frac{1}{2}}$
5. for a multi-step reaction: (a) suggest a reaction mechanism that is consistent with the rate equation and the equation for the overall reaction (b) predict the order that would result from a given reaction mechanism and rate-determining step (c) deduce a rate equation using a given reaction mechanism and rate-determining step for a given reaction (d) identify an intermediate or catalyst from a given reaction mechanism (e) identify the rate determining step from a rate equation and a given reaction mechanism
6. describe qualitatively the effect of temperature change on the rate constant and hence the rate of a reaction
7. explain that catalysts can be **homogeneous** or **heterogeneous**
8. describe the mode of action of a **heterogeneous catalyst** to include **adsorption** of reactants, bond weakening and **desorption** of products, for example: (a) iron in the Haber process (b) palladium, platinum and rhodium in the catalytic removal of oxides of nitrogen from the exhaust gases of car engines
9. describe the mode of action of a homogeneous catalyst by being used in one step and reformed in a later step, for example: (a) atmospheric oxides of nitrogen in the oxidation of atmospheric sulfur dioxide (b) Fe^{2+} or Fe^{3+} in the $I^-/S_2O_8^{2-}$ reaction

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 26 (10 questions, answers on sheet 2)	
Teach the new content	Handout 26 Slide deck 26 Vocabulary list 26	
Practice guided then independent	Exercise sheets 26.1, 26.2 Past-paper sheets 26.1, 26.2	
Check before they leave	Unit test 26 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

27. Group 2

Weeks 40

第 2 族

They should be able to

1. describe and explain qualitatively the trend in the **thermal stability** of the nitrates and carbonates including the effect of ionic radius on the polarisation of the large anion
2. describe and explain qualitatively the variation in solubility and of enthalpy change of solution, $\Delta H^{\ominus}_{\text{sol}}$, of the hydroxides and sulfates in terms of relative magnitudes of the **enthalpy change of hydration** and the **lattice energy**

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 27 (10 questions, answers on sheet 2)	
Teach the new content	Handout 27 Slide deck 27 Vocabulary list 27	
Practice guided then independent	Exercise sheets 27.1 Past-paper sheets 27.1	
Check before they leave	Unit test 27 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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28. Chemistry of transition elements

Weeks 41–43

过渡元素化学

They should be able to

1. define a **transition element** as a **d-block** element which forms one or more stable ions with incomplete d orbitals
2. sketch the shape of a $3d_{xy}$ orbital and $3d_{z^2}$ orbital
3. understand that transition elements have the following properties: (a) they have **variable oxidation states** (b) they behave as **catalysts** (c) they form **complex ions** (d) they form **coloured compounds**
4. explain why transition elements have variable oxidation states in terms of the similarity in energy of the 3d and the 4s sub-shells
5. explain why transition elements behave as catalysts in terms of having more than one stable oxidation state, and vacant d orbitals that are energetically accessible and can form dative bonds with **ligands**
6. explain why transition elements form complex ions in terms of vacant d orbitals that are energetically accessible
7. describe and explain the reactions of transition elements with **ligands** to form **complexes**, including the complexes of copper(II) and cobalt(II) ions with water and ammonia molecules and hydroxide and chloride ions
8. define the term **ligand** as a species that contains a lone pair of electrons that forms a dative covalent bond to a central metal atom/ion
9. understand and use the terms: (a) **monodentate ligand** including as examples H_2O, NH_3, Cl^- and CN^- (b) **bidentate ligand** including as examples 1,2-diaminoethane, en, $H_2NCH_2CH_2NH_2$ and the ethanedioate ion, $C_2O_4^{2-}$ (c) **polydentate ligand** including as an example $EDTA^{4-}$
10. define the term **complex** as a molecule or ion formed by a central metal atom/ion surrounded by one or more ligands
11. describe the geometry (shape and bond angles) of transition element complexes which are **linear**, **square planar**, **tetrahedral** or **octahedral**
12. (a) state what is meant by **coordination number** (b) predict the formula and charge of a complex ion, given the metal ion, its charge or oxidation state, the ligand and its coordination number or geometry
13. explain qualitatively that **ligand exchange** can occur, including the complexes of copper(II) ions and cobalt(II) ions with water and ammonia molecules and hydroxide and chloride ions
14. predict, using $E^{\ominus}$ values, the feasibility of redox reactions involving transition elements and their ions
15. describe the reactions of, and perform calculations involving: (a) $MnO_4^-/C_2O_4^{2-}$ in acid solution given suitable data (b) MnO_4^-/Fe^{2+} in acid solution given suitable data (c) Cu^{2+}/I^- given suitable data
16. perform calculations involving other redox systems given suitable data
17. define and use the terms **degenerate** and **non-degenerate** d orbitals
18. describe the splitting of degenerate d orbitals into two non-degenerate sets of d orbitals of higher energy, and use of ΔE in: (a) octahedral complexes, two higher and three lower d orbitals (b) tetrahedral complexes, three higher and two lower d orbitals
19. explain why transition elements form **coloured compounds** in terms of the frequency of light absorbed as an electron is promoted between two non-degenerate d orbitals
20. describe, in qualitative terms, the effects of different ligands on ΔE, frequency of light absorbed, and hence the **complementary colour** that is observed
21. use the complexes of copper(II) ions and cobalt(II) ions with water and ammonia molecules and hydroxide and chloride ions as examples of ligand exchange affecting the colour observed
22. describe the types of **stereoisomerism** shown by complexes, including those associated with bidentate ligands: (a) geometrical (cis/trans) isomerism, e.g. square planar such as $[Pt(NH_3)_2Cl_2]$ and octahedral such as $[Co(NH_3)_4(H_2O)_2]^{2+}$ and $[Ni(H_2NCH_2CH_2NH_2)_2(H_2O)_2]^{2+}$ (b) optical isomerism, e.g. $[Ni(H_2NCH_2CH_2NH_2)_3]^{2+}$ and $[Ni(H_2NCH_2CH_2NH_2)_2(H_2O)_2]^{2+}$
23. deduce the overall polarity of complexes such as those described in 28.4.1(a) and 28.4.1(b)
24. define the **stability constant**, K_{stab}, of a complex as the equilibrium constant for the formation of the complex ion in a solvent (from its constituent ions or molecules)
25. write an expression for a K_{stab} of a complex ($[H_2O]$ should not be included)

26. use K_{stab} expressions to perform calculations
27. describe and explain ligand exchanges in terms of K_{stab} values and understand that a large K_{stab} is due to the formation of a stable complex ion

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 28 (10 questions, answers on sheet 2)	
Teach the new content	Handout 28 Slide deck 28 Vocabulary list 28	
Practice guided then independent	Exercise sheets 28.1, 28.2, 28.3, 28.4, 28.5 Past-paper sheets 28.1, 28.2, 28.3, 28.4, 28.5	
Check before they leave	Unit test 28 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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29. An introduction to A Level organic chemistry

Weeks 44–45

A Level 有机化学导论

They should be able to

1. understand that the compounds in the table on page 47 contain a **functional group** which dictates their physical and chemical properties
2. interpret and use the general, structural, displayed and skeletal formulas of the classes of compound stated in the table on page 47
3. understand and use **systematic nomenclature** of simple aliphatic organic molecules (including cyclic compounds containing a single ring of up to six carbon atoms) with functional groups detailed in the table on page 47, up to six carbon atoms (six plus six for esters and amides, straight chains only for esters and nitriles)
4. understand and use systematic nomenclature of simple **aromatic** molecules with one **benzene ring** and one or more simple substituents, for example 3-nitrobenzoic acid or 2,4,6-tribromophenol
5. understand and use the following terminology associated with types of organic mechanisms: (a) **electrophilic substitution** (b) **addition–elimination**
6. describe and explain the shape of **benzene** and other aromatic molecules, including sp^2 hybridisation, in terms of σ bonds and a **delocalised** π system
7. understand that **enantiomers** have identical physical and chemical properties apart from their ability to rotate **plane polarised light** and their potential biological activity
8. understand and use the terms **optically active** and **racemic mixture**
9. describe the effect on plane polarised light of the two optical isomers of a single substance
10. explain the relevance of **chirality** to the synthetic preparation of drug molecules including: (a) the potential different biological activity of the two enantiomers (b) the need to separate a racemic mixture into two pure enantiomers (c) the use of chiral catalysts to produce a single pure optical isomer (Candidates should appreciate that compounds can contain more than one chiral centre, but knowledge of meso compounds and nomenclature such as diastereoisomers is not required.)

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 29 (10 questions, answers on sheet 2)	
Teach the new content	Handout 29 Slide deck 29 Vocabulary list 29	
Practice guided then independent	Exercise sheets 29.1, 29.2, 29.3, 29.4 Past-paper sheets 29.1, 29.2, 29.3, 29.4	
Check before they leave	Unit test 29 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

30. Hydrocarbons

Weeks 46

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They should be able to

1. describe the chemistry of **arenes** as exemplified by the following reactions of benzene and methylbenzene: (a) substitution reactions with Cl_2 and with Br_2 in the presence of a catalyst, $AlCl_3$ or $AlBr_3$, to form halogenoarenes (aryl halides) (b) **nitration** with a mixture of concentrated HNO_3 and concentrated H_2SO_4 at a temperature between 25 °C and 60 °C (c) **Friedel–Crafts alkylation** by CH_3Cl and $AlCl_3$ and heat (d) **Friedel–Crafts acylation** by CH_3COCl and $AlCl_3$ and heat (e) complete oxidation of the side-chain using hot alkaline $KMnO_4$ and then dilute acid to give a benzoic acid (f) hydrogenation of the benzene ring using H_2 and Pt/Ni catalyst and heat to form a cyclohexane ring
2. describe the mechanism of **electrophilic substitution** in arenes: (a) as exemplified by the formation of nitrobenzene and bromobenzene (b) with regards to the effect of delocalisation (aromatic stabilisation) of electrons in arenes to explain the predomination of substitution over addition
3. predict whether halogenation will occur in the side-chain or in the aromatic ring in arenes depending on reaction conditions
4. describe that in the electrophilic substitution of arenes, different substituents direct to different ring positions (limited to the directing effects of $-NH_2$, $-OH$, $-R$, $-NO_2$, $-COOH$ and $-COR$)

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 30 (10 questions, answers on sheet 2)	
Teach the new content	Handout 30 Slide deck 30 Vocabulary list 30	
Practice guided then independent	Exercise sheets 30.1 Past-paper sheets 30.1	
Check before they leave	Unit test 30 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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31. Halogen compounds

Weeks 47

卤素化合物

They should be able to

1. recall the reactions by which **halogenoarenes** can be produced: substitution of an arene with Cl_2 or Br_2 in the presence of a catalyst, $AlCl_3$ or $AlBr_3$ to form a halogenoarene, exemplified by benzene to form chlorobenzene and methylbenzene to form 2-chloromethylbenzene and 4-chloromethylbenzene
2. explain the difference in reactivity between a **halogenoalkane** and a **halogenoarene** as exemplified by chloroethane and chlorobenzene

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 31 (10 questions, answers on sheet 2)	
Teach the new content	Handout 31 Slide deck 31 Vocabulary list 31	
Practice guided then independent	Exercise sheets 31.1 Past-paper sheets 31.1	
Check before they leave	*nothing in the Library for this stage yet*	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

32. Hydroxy compounds

Weeks 48

羟基化合物

They should be able to

1. describe the reaction with **acyl chlorides** to form **esters** using ethyl ethanoate
2. recall the reactions (reagents and conditions) by which phenol can be produced: (a) reaction of phenylamine with HNO_2 or $NaNO_2$ and dilute acid below 10 °C to produce the **diazonium salt**; further warming of the diazonium salt with H_2O to give phenol
3. recall the chemistry of phenol, as exemplified by the following reactions: (a) with bases, for example NaOH(aq) to produce sodium phenoxide (b) with Na(s) to produce sodium phenoxide and H_2(g) (c) in NaOH(aq) with diazonium salts, to give **azo compounds** (d) nitration of the aromatic ring with dilute HNO_3(aq) at room temperature to give a mixture of 2-nitrophenol and 4-nitrophenol (e) bromination of the aromatic ring with Br_2(aq) to form 2,4,6-tribromophenol
4. explain the **acidity** of phenol
5. describe and explain the relative acidities of water, phenol and ethanol
6. explain why the reagents and conditions for the nitration and bromination of phenol are different from those for benzene
7. recall that the hydroxyl group of a phenol directs to the 2-, 4- and 6-positions
8. apply knowledge of the reactions of phenol to those of other phenolic compounds, e.g. naphthol

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 32 (10 questions, answers on sheet 2)	
Teach the new content	Handout 32 Slide deck 32 Vocabulary list 32	
Practice guided then independent	Exercise sheets 32.1, 32.2 Past-paper sheets 32.1, 32.2	
Check before they leave	Unit test 32 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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33. Carboxylic acids and derivatives

Weeks 49–50

羧酸及其衍生物

They should be able to

1. recall the reaction by which benzoic acid can be produced: (a) reaction of an alkylbenzene with hot alkaline $KMnO_4$ and then dilute acid, exemplified by methylbenzene
2. describe the reaction of carboxylic acids with PCl_3 and heat, PCl_5 or $SOCl_2$ to form **acyl chlorides**
3. recognise that some carboxylic acids can be further oxidised: (a) the oxidation of methanoic acid, HCOOH, with Fehling's reagent or Tollens' reagent or acidified $KMnO_4$ or acidified $K_2Cr_2O_7$ to carbon dioxide and water (b) the oxidation of ethanedioic acid, HOOCCOOH, with warm acidified $KMnO_4$ to carbon dioxide
4. describe and explain the **relative acidities** of carboxylic acids, phenols and alcohols
5. describe and explain the relative acidities of chlorine-substituted carboxylic acids
6. recall the reaction by which esters can be produced: (a) reaction of alcohols with **acyl chlorides** using the formation of ethyl ethanoate and phenyl benzoate as examples
7. recall the reactions (reagents and conditions) by which **acyl chlorides** can be produced: (a) reaction of carboxylic acids with PCl_3 and heat, PCl_5 or $SOCl_2$
8. describe the following reactions of acyl chlorides: (a) hydrolysis on addition of water at room temperature to give the carboxylic acid and HCl (b) reaction with an alcohol at room temperature to produce an ester and HCl (c) reaction with phenol at room temperature to produce an ester and HCl (d) reaction with ammonia at room temperature to produce an amide and HCl (e) reaction with a primary or secondary amine at room temperature to produce an amide and HCl
9. describe the **addition–elimination mechanism** of acyl chlorides in reactions in 33.3.2(a)–(e)
10. explain the relative ease of hydrolysis of acyl chlorides, alkyl chlorides and halogenoarenes (aryl chlorides)

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 33 (10 questions, answers on sheet 2)	
Teach the new content	Handout 33 Slide deck 33 Vocabulary list 33	
Practice guided then independent	Exercise sheets 33.1, 33.2, 33.3 Past-paper sheets 33.1, 33.2, 33.3	
Check before they leave	Unit test 33 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

34. Nitrogen compounds

Weeks 51–52

含氮化合物

They should be able to

1. recall the reactions (reagents and conditions) by which **primary and secondary amines** are produced: (a) reaction of halogenoalkanes with NH_3 in ethanol heated under pressure (b) reaction of halogenoalkanes with primary amines in ethanol, heated in a sealed tube/under pressure (c) the reduction of amides with $LiAlH_4$ (d) the reduction of nitriles with $LiAlH_4$ or H_2/Ni
2. describe the **condensation reaction** of ammonia or an amine with an acyl chloride at room temperature to give an **amide**
3. describe and explain the **basicity** of aqueous solutions of amines
4. describe the preparation of **phenylamine** via the nitration of benzene to form nitrobenzene followed by reduction with hot Sn/concentrated HCl followed by NaOH(aq)
5. describe: (a) the reaction of phenylamine with Br_2(aq) at room temperature (b) the reaction of phenylamine with HNO_2 or $NaNO_2$ and dilute acid below 10 °C to produce the diazonium salt; further warming of the diazonium salt with H_2O to give phenol
6. describe and explain the **relative basicities** of aqueous ammonia, ethylamine and phenylamine
7. recall the following about **azo compounds**: (a) describe the coupling of benzenediazonium chloride with phenol in NaOH(aq) to form an azo compound (b) identify the azo group (c) state that azo compounds are often used as dyes (d) that other azo dyes can be formed via a similar route
8. recall the reactions (reagents and conditions) by which **amides** are produced: (a) the reaction between ammonia and an acyl chloride at room temperature (b) the reaction between a primary amine and an acyl chloride at room temperature
9. describe the reactions of amides: (a) hydrolysis with aqueous alkali or aqueous acid (b) the reduction of the CO group in amides with $LiAlH_4$ to form an amine
10. state and explain why amides are much **weaker bases** than amines
11. describe the acid/base properties of **amino acids** and the formation of **zwitterions**, to include the **isoelectric point**
12. describe the formation of **amide (peptide) bonds** between amino acids to give di- and tripeptides
13. interpret and predict the results of **electrophoresis** on mixtures of amino acids and dipeptides at varying pHs (the assembling of the apparatus will not be tested)

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 34 (10 questions, answers on sheet 2)	
Teach the new content	Handout 34 Slide deck 34 Vocabulary list 34	
Practice guided then independent	Exercise sheets 34.1, 34.2, 34.3, 34.4 Past-paper sheets 34.1, 34.2, 34.3, 34.4	
Check before they leave	Unit test 34 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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35. Polymerisation

Weeks 53

聚合

They should be able to

1. describe the formation of **polyesters**: (a) the reaction between a diol and a dicarboxylic acid or dioyl chloride (b) the reaction of a hydroxycarboxylic acid
2. describe the formation of **polyamides**: (a) the reaction between a diamine and a dicarboxylic acid or dioyl chloride (b) the reaction of an aminocarboxylic acid (c) the reaction between amino acids
3. deduce the **repeat unit** of a **condensation polymer** obtained from a given **monomer** or pair of monomers
4. identify the monomer(s) present in a given section of a condensation polymer molecule
5. predict the type of **polymerisation** reaction for a given monomer or pair of monomers
6. deduce the type of polymerisation reaction which produces a given section of a polymer molecule
7. recognise that poly(alkenes) are chemically inert and can therefore be difficult to **biodegrade**
8. recognise that some polymers can be degraded by the action of light
9. recognise that polyesters and polyamides are **biodegradable** by acidic and alkaline **hydrolysis**

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 35 (10 questions, answers on sheet 2)	
Teach the new content	Handout 35 Slide deck 35 Vocabulary list 35	
Practice guided then independent	Exercise sheets 35.1, 35.2, 35.3 Past-paper sheets 35.1, 35.2, 35.3	
Check before they leave	*nothing in the Library for this stage yet*	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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36. Organic synthesis

Weeks 54

有机合成

They should be able to

1. for an organic molecule containing several **functional groups**: (a) identify organic functional groups using the reactions in the syllabus (b) predict properties and reactions
2. devise **multi-step synthetic routes** for preparing organic molecules using the reactions in the syllabus
3. analyse a given synthetic route in terms of type of reaction and reagents used for each step of it, and possible by-products

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 36 (10 questions, answers on sheet 2)	
Teach the new content	Handout 36 Slide deck 36 Vocabulary list 36	
Practice guided then independent	Exercise sheets 36.1 Past-paper sheets 36.1	
Check before they leave	Unit test 36 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

37. Analytical techniques

Weeks 55–56

分析技术

They should be able to

1. describe and understand the terms (a) **stationary phase**, for example aluminium oxide (on a solid support) (b) **mobile phase**; a polar or non-polar solvent (c) R_f value (d) solvent front and baseline
2. interpret R_f values
3. explain the differences in R_f values in terms of interaction with the stationary phase and of relative solubility in the mobile phase
4. describe and understand the terms (a) **stationary phase**; a high boiling point non-polar liquid (on a solid support) (b) mobile phase; an unreactive gas (c) **retention time**
5. interpret gas/liquid chromatograms in terms of the percentage composition of a mixture
6. explain retention times in terms of interaction with the stationary phase
7. analyse and interpret a **carbon-13 NMR** spectrum of a simple molecule to deduce: (a) the different environments of the carbon atoms present (b) the possible structures for the molecule
8. predict or explain the number of peaks in a carbon-13 NMR spectrum for a given molecule
9. analyse and interpret a proton (^{1}H) NMR spectrum of a simple molecule to deduce: (a) the different environments of proton present using **chemical shift** values (b) the relative numbers of each type of proton present from relative peak areas (c) the number of equivalent protons on the carbon atom adjacent to the one to which the given proton is attached from the **splitting pattern**, using the $n + 1$ rule (limited to singlet, doublet, triplet, quartet and multiplet) (d) the possible structures for the molecule
10. predict the chemical shifts and splitting patterns of the protons in a given molecule
11. describe the use of **tetramethylsilane**, TMS, as the standard for chemical shift measurements
12. state the need for deuterated solvents, e.g. $CDCl_3$, when obtaining a proton NMR spectrum
13. describe the identification of O–H and N–H protons by proton exchange using D_2O

Stage	Use	Your notes
Starter 10 min · retrieval practice	Topic quiz 37 (10 questions, answers on sheet 2)	
Teach the new content	Handout 37 Slide deck 37 Vocabulary list 37	
Practice guided then independent	Exercise sheets 37.1, 37.2, 37.3, 37.4 Past-paper sheets 37.1, 37.2, 37.3, 37.4	
Check before they leave	Unit test 37 (with mark scheme)	
Homework set from the Library	Any unused exercise sheet above Holiday homework pack	

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