SYLLABUS CHECKLIST

Cambridge International AS & A Level Chemistry 9701

Exams in 2025, 2026 and 2027 · 415 items

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AS Level: physical chemistry

1 Atomic structure

- [ ] **1.1.1** Atom: mostly empty space, small dense nucleus, electrons in shells
- [ ] **1.1.2** Relative charges and masses of protons, neutrons and electrons
- [ ] **1.1.3** Proton (atomic) number and nucleon (mass) number
- [ ] **1.1.4** How mass and charge are distributed in an atom
- [ ] **1.1.5** Behaviour of beams of protons, neutrons and electrons in an electric field
- [ ] **1.1.6** Numbers of protons, neutrons and electrons in atoms and ions
- [ ] **1.1.7** Trends in atomic and ionic radius across a period and down a group
- [ ] **1.2.1** Isotopes: same protons, different neutrons
- [ ] **1.2.2** Isotope notation (mass number and proton number on the symbol)
- [ ] **1.2.3** Isotopes have the same chemical properties, and why
- [ ] **1.2.4** Isotopes have different physical properties (mass, density), and why
- [ ] **1.3.1** Shells, sub-shells and orbitals; principal quantum number n; ground state
- [ ] **1.3.2** Number of orbitals in s, p and d sub-shells and their electron capacity
- [ ] **1.3.3** Order of sub-shell energies in the first three shells, plus 4s and 4p
- [ ] **1.3.4** Electronic configurations: electrons per shell, sub-shell and orbital
- [ ] **1.3.5** Explain configurations using electron energy and electron–electron repulsion
- [ ] **1.3.6** Full and shorthand configurations of atoms and ions
- [ ] **1.3.7** Electrons-in-boxes notation
- [ ] **1.3.8** Shapes of s and p orbitals
- [ ] **1.3.9** Free radical: a species with one or more unpaired electrons
- [ ] **1.4.1** First ionisation energy: definition
- [ ] **1.4.2** Equations for first, second and successive ionisation energies
- [ ] **1.4.3** Ionisation energy trends across a period and down a group
- [ ] **1.4.4** Patterns in successive ionisation energies
- [ ] **1.4.5** Ionisation energy and nucleus–outer electron attraction
- [ ] **1.4.6** Factors: nuclear charge, atomic radius, shielding, spin-pair repulsion
- [ ] **1.4.7** Deduce configuration from successive ionisation energies
- [ ] **1.4.8** Deduce an element's position in the Periodic Table from successive ionisation energies

2 Atoms, molecules and stoichiometry

- [ ] **2.1.1** Unified atomic mass unit: one twelfth of the mass of a carbon-12 atom
- [ ] **2.1.2** Relative atomic mass, relative isotopic mass, relative molecular mass, relative formula mass
- [ ] **2.2.1** The mole and the Avogadro constant

- [ ] **2.3.1** Formulas of ionic compounds from ionic charges and oxidation numbers (Roman numerals)
- [ ] **2.3.1a** Predict ionic charges from Periodic Table position
- [ ] **2.3.1b** Names and formulas of NO_3^-, CO_3^{2-}, SO_4^{2-}, OH^-, NH_4^+, Zn^{2+}, Ag^+, HCO_3^-, PO_4^{3-}
- [ ] **2.3.2a** Balanced equations, including ionic equations without spectator ions
- [ ] **2.3.2b** State symbols
- [ ] **2.3.3** Empirical and molecular formulas
- [ ] **2.3.4** Anhydrous, hydrated and water of crystallisation
- [ ] **2.3.5** Calculate empirical and molecular formulas from data
- [ ] **2.4.1a** Reacting masses, including percentage yield
- [ ] **2.4.1b** Volumes of gases (e.g. combustion of hydrocarbons)
- [ ] **2.4.1c** Volumes and concentrations of solutions
- [ ] **2.4.1d** Limiting and excess reagents
- [ ] **2.4.1e** Deduce stoichiometric relationships from calculations

3 Chemical bonding

- [ ] **3.1.1** Electronegativity: definition
- [ ] **3.1.2** Factors affecting electronegativity: nuclear charge, radius, shielding
- [ ] **3.1.3** Electronegativity trends across a period and down a group
- [ ] **3.1.4** Pauling electronegativity differences predict ionic or covalent bonding
- [ ] **3.2.1** Ionic bonding: electrostatic attraction between oppositely charged ions
- [ ] **3.2.2** Ionic bonding in NaCl, MgO and CaF_2
- [ ] **3.3.1** Metallic bonding: positive ions in a sea of delocalised electrons
- [ ] **3.4.1** Covalent bonding: a shared pair of electrons attracted to two nuclei
- [ ] **3.4.1a** Covalent bonding in H_2, O_2, N_2, Cl_2, HCl, CO_2, NH_3, CH_4, C_2H_6, C_2H_4
- [ ] **3.4.1b** Expanded octets: SO_2, PCl_5, SF_6
- [ ] **3.4.1c** Coordinate (dative) bonding: NH_4^+ and Al_2Cl_6
- [ ] **3.4.2a** σ and π bonds from orbital overlap
- [ ] **3.4.2b** σ and π bonding in H_2, C_2H_6, C_2H_4, HCN and N_2
- [ ] **3.4.2c** Hybridisation: sp, sp^2 and sp^3
- [ ] **3.4.3a** Bond energy and bond length: definitions
- [ ] **3.4.3b** Using bond energies and lengths to compare reactivity
- [ ] **3.5.1** VSEPR shapes and bond angles: BF_3, CO_2, CH_4, NH_3, H_2O, SF_6, PF_5
- [ ] **3.5.2** Predict the shapes and angles of similar molecules and ions
- [ ] **3.6.1a** Hydrogen bonding through N–H and O–H: ammonia and water
- [ ] **3.6.1b** Anomalous properties of water: high m.p./b.p., surface tension, ice less dense
- [ ] **3.6.2** Electronegativity, bond polarity and dipole moments
- [ ] **3.6.3a** van der Waals' forces as the general term
- [ ] **3.6.3b** Instantaneous dipole–induced dipole (London) and permanent dipole–permanent dipole forces
- [ ] **3.6.3c** Hydrogen bonding as a special case of permanent dipole forces
- [ ] **3.6.4** Ionic, covalent and metallic bonds are stronger than intermolecular forces
- [ ] **3.7.1** Dot-and-cross diagrams for ionic, covalent and coordinate bonding

4 States of matter

- [ ] **4.1.1** Gas pressure from particle collisions with container walls
- [ ] **4.1.2** Ideal gas assumptions: no particle volume, no intermolecular forces

- [ ] **4.1.3** Ideal gas equation pV = nRT, including finding Mr
- [ ] **4.2.1a** Giant ionic lattices: NaCl, MgO
- [ ] **4.2.1b** Simple molecular lattices: iodine, C_{60} (buckminsterfullerene), ice
- [ ] **4.2.1c** Giant molecular lattices: SiO_2, graphite, diamond
- [ ] **4.2.1d** Giant metallic lattice: copper
- [ ] **4.2.2** Predict physical properties from structure and bonding
- [ ] **4.2.3** Deduce structure and bonding from given information

5 Chemical energetics

- [ ] **5.1.1** Exothermic and endothermic changes; the sign of ΔH
- [ ] **5.1.2** Reaction pathway diagrams showing ΔH and activation energy
- [ ] **5.1.3** Standard conditions (298 K, 101 kPa); ΔHr, ΔHf, ΔHc and ΔHneut
- [ ] **5.1.4** Bond breaking is endothermic, bond making exothermic
- [ ] **5.1.5** ΔHr from bond energies
- [ ] **5.1.6** Exact bond energies versus average bond energies
- [ ] **5.1.7** Enthalpy changes from experiments: $q = mc\Delta T$, $\Delta H = -mc\Delta T \div n$
- [ ] **5.2.1** Hess's law and energy cycles
- [ ] **5.2.2a** Enthalpy changes that cannot be measured directly
- [ ] **5.2.2b** Calculations using bond energy data

6 Electrochemistry

- [ ] **6.1.1** Oxidation numbers in compounds and ions
- [ ] **6.1.2** Balancing equations using changes in oxidation number
- [ ] **6.1.3** Redox, oxidation, reduction and disproportionation (electrons and oxidation numbers)
- [ ] **6.1.4** Oxidising and reducing agents
- [ ] **6.1.5** Roman numerals for oxidation numbers

7 Equilibria

- [ ] **7.1.1a** Reversible reactions
- [ ] **7.1.1b** Dynamic equilibrium: equal forward and reverse rates, constant concentrations
- [ ] **7.1.1c** A closed system is needed for dynamic equilibrium
- [ ] **7.1.2** Le Chatelier's principle
- [ ] **7.1.3** Effects of temperature, concentration, pressure and catalysts on equilibrium position
- [ ] **7.1.4** Writing Kc expressions
- [ ] **7.1.5** Mole fraction and partial pressure
- [ ] **7.1.6** Writing Kp expressions
- [ ] **7.1.7** Kc and Kp calculations (no quadratic equations)
- [ ] **7.1.8** Calculating amounts present at equilibrium
- [ ] **7.1.9** Which changes alter the value of K (only temperature)
- [ ] **7.1.10** Conditions in the Haber and Contact processes
- [ ] **7.2.1** Common acids: HCl, H_2SO_4, HNO_3, CH_3COOH
- [ ] **7.2.2** Common alkalis: NaOH, KOH, NH_3
- [ ] **7.2.3** Brønsted–Lowry theory of acids and bases
- [ ] **7.2.4** Strong and weak acids and bases: full versus partial dissociation
- [ ] **7.2.5** The pH scale
- [ ] **7.2.6** Telling strong and weak acids apart: reaction with metals, pH

- [ ] **7.2.7** Neutralisation: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
- [ ] **7.2.8** Salts form in neutralisation
- [ ] **7.2.9** pH titration curves for strong/weak acid and base combinations
- [ ] **7.2.10** Choosing an indicator for a titration

8 Reaction kinetics

- [ ] **8.1.1** Rate of reaction; collision frequency; effective and non-effective collisions
- [ ] **8.1.2** Effect of concentration and pressure on rate
- [ ] **8.1.3** Calculating rate from experimental data
- [ ] **8.2.1** Activation energy: the minimum energy for a successful collision
- [ ] **8.2.2** Boltzmann distribution: sketch and meaning
- [ ] **8.2.3** Effect of temperature on rate, using the Boltzmann distribution
- [ ] **8.3.1a** Catalysts provide a route with lower activation energy
- [ ] **8.3.1b** Catalysis explained using the Boltzmann distribution
- [ ] **8.3.1c** Reaction pathway diagrams with and without a catalyst

AS Level: inorganic chemistry

9 The Periodic Table: chemical periodicity

- [ ] **9.1.1** Period 3 trends: atomic radius, ionic radius, melting point, electrical conductivity
- [ ] **9.1.2** Explain melting point and conductivity trends from structure and bonding
- [ ] **9.2.1** Period 3 elements with oxygen, chlorine and water (Na and Mg only with water)
- [ ] **9.2.2** Oxidation numbers of the oxides and chlorides from outer electrons
- [ ] **9.2.3** Oxides with water, and the pH of the solutions
- [ ] **9.2.4** Acid–base behaviour of the oxides and hydroxides; amphoteric Al_2O_3 with NaOH
- [ ] **9.2.5** Chlorides with water, and the pH of the solutions
- [ ] **9.2.6** Explain these trends using bonding and electronegativity
- [ ] **9.2.7** Deduce the type of bonding from chemical and physical properties
- [ ] **9.3.1** Predict the properties of an element in a group
- [ ] **9.3.2** Deduce the identity and position of an unknown element

10 Group 2

- [ ] **10.1.1** Mg to Ba with oxygen, water, dilute HCl and dilute H_2SO_4
- [ ] **10.1.2** Oxides, hydroxides and carbonates with water and dilute acids
- [ ] **10.1.3** Thermal decomposition of nitrates and carbonates; trend in stability
- [ ] **10.1.4** Predict trends in properties and reactions down the group
- [ ] **10.1.5** Solubility trends of the hydroxides and sulfates

11 Group 17

- [ ] **11.1.1** Colours and trend in volatility of Cl_2, Br_2 and I_2
- [ ] **11.1.2** Trend in bond strength of the halogen molecules
- [ ] **11.1.3** Volatility explained by instantaneous dipole–induced dipole forces
- [ ] **11.2.1** Relative oxidising power of the halogens (displacement)
- [ ] **11.2.2** Reactions with hydrogen and relative reactivity
- [ ] **11.2.3** Thermal stability of the hydrogen halides and bond strengths
- [ ] **11.3.1** Relative reducing power of halide ions
- [ ] **11.3.2a** Halide ions with aqueous silver ions, then aqueous ammonia

- [ ] **11.3.2b** Halide ions with concentrated sulfuric acid
- [ ] **11.4.1** Chlorine with cold and hot aqueous NaOH: disproportionation
- [ ] **11.4.2** Chlorine in water purification: HOCl and ClO^-

12 Nitrogen and sulfur

- [ ] **12.1.1** Why nitrogen is unreactive: strong triple bond, no polarity
- [ ] **12.1.2a** Basicity of ammonia (Brønsted–Lowry)
- [ ] **12.1.2b** Structure and formation of the ammonium ion
- [ ] **12.1.2c** Displacing ammonia from ammonium salts
- [ ] **12.1.3** Natural and man-made NOx; catalytic removal from car exhausts
- [ ] **12.1.4** NOx and unburnt hydrocarbons form PAN (photochemical smog)
- [ ] **12.1.5** NO and NO_2 in acid rain, including catalysing the oxidation of SO_2

AS Level: organic chemistry and analysis

13 An introduction to AS Level organic chemistry

- [ ] **13.1.1** Hydrocarbons contain C and H only
- [ ] **13.1.2** Alkanes have no functional group
- [ ] **13.1.3** Functional groups decide properties
- [ ] **13.1.4** General, structural, displayed and skeletal formulas
- [ ] **13.1.5** Systematic names up to six carbons
- [ ] **13.1.6** Molecular and empirical formulas from a structure
- [ ] **13.2.1a** Homologous series
- [ ] **13.2.1b** Saturated and unsaturated
- [ ] **13.2.1c** Homolytic and heterolytic fission
- [ ] **13.2.1d** Free radicals: initiation, propagation, termination
- [ ] **13.2.1e** Nucleophiles and electrophiles
- [ ] **13.2.1f** Addition, substitution, elimination, hydrolysis, condensation
- [ ] **13.2.1g** Oxidation [O] and reduction [H]
- [ ] **13.2.2a** Free-radical substitution mechanism
- [ ] **13.2.2b** Electrophilic addition mechanism
- [ ] **13.2.2c** Nucleophilic substitution mechanism
- [ ] **13.2.2d** Nucleophilic addition mechanism
- [ ] **13.3.1** Straight-chain, branched and cyclic molecules
- [ ] **13.3.2** Shapes and bond angles around sp, sp^2 and sp^3 carbons
- [ ] **13.3.3** Arrangement of σ and π bonds
- [ ] **13.3.4** Planar arrangement around C=C (ethene)
- [ ] **13.4.1** Structural isomerism: chain, positional, functional group
- [ ] **13.4.2** Stereoisomerism: geometrical (cis/trans) and optical
- [ ] **13.4.3** cis/trans isomerism from restricted rotation about a π bond
- [ ] **13.4.4** A chiral centre gives a pair of enantiomers
- [ ] **13.4.5** Identify chiral centres and cis/trans isomerism in a formula
- [ ] **13.4.6** Deduce possible isomers from a molecular formula

14 Hydrocarbons

- [ ] **14.1.1a** Alkanes from alkenes: H_2, Pt or Ni catalyst, heat

- [ ] **14.1.1b** Alkanes by cracking: heat with Al_2O_3
- [ ] **14.1.2a** Complete and incomplete combustion of alkanes
- [ ] **14.1.2b** Free-radical substitution with Cl_2 or Br_2 in UV light (ethane)
- [ ] **14.1.3** Free-radical mechanism: initiation, propagation, termination
- [ ] **14.1.4** Cracking to make useful smaller molecules
- [ ] **14.1.5** Why alkanes are unreactive: strong C–H bonds, low polarity
- [ ] **14.1.6** Effects of CO, NOx and unburnt hydrocarbons; catalytic converters
- [ ] **14.2.1a** Alkenes from halogenoalkanes: ethanolic NaOH, heat
- [ ] **14.2.1b** Alkenes by dehydrating alcohols: Al_2O_3 or concentrated H_2SO_4
- [ ] **14.2.1c** Alkenes by cracking
- [ ] **14.2.2a** Addition of H_2 (Pt/Ni, heat), steam (H_3PO_4), HX and X_2
- [ ] **14.2.2b** Cold dilute acidified $KMnO_4$ gives a diol
- [ ] **14.2.2c** Hot concentrated acidified $KMnO_4$ splits the C=C
- [ ] **14.2.2d** Addition polymerisation (ethene, propene)
- [ ] **14.2.3** Test for C=C: decolourises aqueous bromine
- [ ] **14.2.4** Electrophilic addition mechanism (Br_2 + ethene, HBr + propene)
- [ ] **14.2.5** Inductive effect of alkyl groups, carbocation stability, Markovnikov's rule

15 Halogen compounds

- [ ] **15.1.1** Making halogenoalkanes from alkanes, alkenes and alcohols (HX, KCl/H_2SO_4, PCl_3, PCl_5, $SOCl_2$)
- [ ] **15.1.2** Primary, secondary and tertiary halogenoalkanes
- [ ] **15.1.3a** With NaOH(aq), heat: alcohol
- [ ] **15.1.3b** With KCN in ethanol, heat: nitrile
- [ ] **15.1.3c** With NH_3 in ethanol under pressure: amine
- [ ] **15.1.3d** Test for the halogen: aqueous $AgNO_3$ in ethanol
- [ ] **15.1.4** Elimination: NaOH in ethanol, heat, gives an alkene
- [ ] **15.1.5** SN1 and SN2 mechanisms; inductive effect of alkyl groups
- [ ] **15.1.6** Primary by SN2, tertiary by SN1, secondary by both
- [ ] **15.1.7** Reactivity and C–X bond strength (rates with $AgNO_3$)

16 Hydroxy compounds

- [ ] **16.1.1** Making alcohols: hydration, $KMnO_4$ (diols), hydrolysis, $NaBH_4$/$LiAlH_4$ reduction, ester hydrolysis
- [ ] **16.1.2a** Combustion of alcohols
- [ ] **16.1.2b** Substitution to halogenoalkanes
- [ ] **16.1.2c** Reaction with sodium
- [ ] **16.1.2d** Oxidation: distil for carbonyls, reflux for carboxylic acids
- [ ] **16.1.2e** Dehydration to alkenes
- [ ] **16.1.2f** Esterification with carboxylic acids (concentrated H_2SO_4)
- [ ] **16.1.3a** Primary, secondary and tertiary alcohols
- [ ] **16.1.3b** Telling them apart with acidified $K_2Cr_2O_7$ (orange to green)
- [ ] **16.1.4** Iodoform test for $CH_3CH(OH)$–: alkaline I_2, yellow precipitate
- [ ] **16.1.5** Acidity of alcohols compared with water

17 Carbonyl compounds

- [ ] **17.1.1** Aldehydes and ketones by oxidising primary and secondary alcohols
- [ ] **17.1.2a** Reduction to alcohols with $NaBH_4$ or $LiAlH_4$
- [ ] **17.1.2b** Hydroxynitriles with HCN and KCN (ethanal, propanone)
- [ ] **17.1.3** Nucleophilic addition mechanism with HCN
- [ ] **17.1.4** Test for C=O: 2,4-DNPH (orange precipitate)
- [ ] **17.1.5** Telling aldehydes from ketones: Fehling's and Tollens' reagents
- [ ] **17.1.6** Iodoform test for $CH_3CO–$

18 Carboxylic acids and derivatives

- [ ] **18.1.1** Making carboxylic acids: oxidising alcohols/aldehydes, hydrolysing nitriles and esters
- [ ] **18.1.2a** With reactive metals: salt + H_2
- [ ] **18.1.2b** With alkalis: salt + water
- [ ] **18.1.2c** With carbonates: salt + water + CO_2
- [ ] **18.1.2d** Esterification with alcohols
- [ ] **18.1.2e** Reduction by $LiAlH_4$ to primary alcohols
- [ ] **18.2.1** Esters from alcohols and carboxylic acids (concentrated H_2SO_4)
- [ ] **18.2.2** Ester hydrolysis by dilute acid and by dilute alkali

19 Nitrogen compounds

- [ ] **19.1.1** Primary amines from halogenoalkanes and ammonia
- [ ] **19.2.1** Nitriles from halogenoalkanes and KCN
- [ ] **19.2.2** Hydroxynitriles from aldehydes and ketones with HCN/KCN
- [ ] **19.2.3** Hydrolysis of nitriles to carboxylic acids

20 Polymerisation

- [ ] **20.1.1** Addition polymers: poly(ethene) and PVC
- [ ] **20.1.2** Repeat unit from a monomer
- [ ] **20.1.3** Monomer from a section of polymer
- [ ] **20.1.4** Disposal problems: non-biodegradable, harmful combustion products

21 Organic synthesis

- [ ] **21.1.1** Identify functional groups and predict the reactions of multifunctional molecules
- [ ] **21.1.2** Devise multi-step synthetic routes
- [ ] **21.1.3** Analyse a route: reaction types, reagents, by-products

22 Analytical techniques

- [ ] **22.1.1** Infrared spectra: identify functional groups
- [ ] **22.2.1** Mass spectra: m/e values and isotopic abundances
- [ ] **22.2.2** Relative atomic mass from isotope abundances or a spectrum
- [ ] **22.2.3** Relative molecular mass from the molecular ion peak
- [ ] **22.2.4** Identify fragment ions
- [ ] **22.2.5** Number of carbon atoms from the $[M+1]^+$ peak
- [ ] **22.2.6** Chlorine or bromine from the $[M+2]^+$ peak

A Level: physical chemistry

23 Chemical energetics

- [ ] **23.1.1** Enthalpy change of atomisation and lattice energy
- [ ] **23.1.2** First electron affinity: factors affecting it, trends in Groups 16 and 17
- [ ] **23.1.3** Constructing Born–Haber cycles
- [ ] **23.1.4** Born–Haber calculations
- [ ] **23.1.5** Effect of ionic charge and radius on lattice energy
- [ ] **23.2.1** Enthalpy change of hydration and of solution
- [ ] **23.2.2** Energy cycles linking solution, lattice and hydration enthalpies
- [ ] **23.2.3** Calculations with these cycles
- [ ] **23.2.4** Effect of ionic charge and radius on hydration enthalpy
- [ ] **23.3.1** Entropy as the number of ways of arranging particles and energy
- [ ] **23.3.2** Sign of ΔS for melting, boiling, dissolving, temperature change and change in gas moles
- [ ] **23.3.3** $\Delta S = \Sigma S°(\text{products}) - \Sigma S°(\text{reactants})$
- [ ] **23.4.1** Gibbs equation: $\Delta G° = \Delta H° - T\Delta S°$
- [ ] **23.4.2** Calculations with the Gibbs equation
- [ ] **23.4.3** Feasibility from the sign of ΔG
- [ ] **23.4.4** Effect of temperature on feasibility

24 Electrochemistry

- [ ] **24.1.1** Products of electrolysis: state, position in redox series, concentration
- [ ] **24.1.2** F = Le
- [ ] **24.1.3** Q = It; mass and volume of substance liberated
- [ ] **24.1.4** Finding the Avogadro constant by electrolysis
- [ ] **24.2.1** Standard electrode potential and standard cell potential
- [ ] **24.2.2** The standard hydrogen electrode
- [ ] **24.2.3** Measuring E° for metals, non-metals and ions in different oxidation states
- [ ] **24.2.4** Standard cell potential from two electrode potentials
- [ ] **24.2.5** Electrode polarity, direction of electron flow, feasibility from E°cell
- [ ] **24.2.6** Relative strength of oxidising and reducing agents from E°
- [ ] **24.2.7** Redox equations from half-equations
- [ ] **24.2.8** Qualitative effect of concentration on E
- [ ] **24.2.9** Nernst equation: $E = E° + (0.059 \div z) \log([\text{oxidised}] \div [\text{reduced}])$
- [ ] **24.2.10** $\Delta G° = -nE°\text{cell } F$

25 Equilibria

- [ ] **25.1.1** Conjugate acids and conjugate bases
- [ ] **25.1.2** Identifying conjugate acid–base pairs
- [ ] **25.1.3** pH, Ka, pKa and Kw: definitions and calculations
- [ ] **25.1.4** $[H^+]$ and pH of strong acids, strong alkalis and weak acids
- [ ] **25.1.5** Buffers: definition, how they are made, how they work, uses (HCO_3^- in blood)
- [ ] **25.1.6** pH of buffer solutions
- [ ] **25.1.7** Solubility product Ksp
- [ ] **25.1.8** Writing Ksp expressions
- [ ] **25.1.9** Ksp and solubility calculations

- [ ] **25.1.10** Common ion effect, with calculations
- [ ] **25.2.1** Partition coefficient Kpc
- [ ] **25.2.2** Calculations with Kpc
- [ ] **25.2.3** Factors affecting Kpc: polarity of solvent and solute

26 Reaction kinetics

- [ ] **26.1.1** Rate equation, order, rate constant, half-life, rate-determining step, intermediate
- [ ] **26.1.2** rate = k[A]^m[B]^n with orders 0, 1, 2; orders from graphs, initial rates and half-lives
- [ ] **26.1.3** First-order half-life is constant; calculations
- [ ] **26.1.4** Rate constant from initial rates and from k = 0.693 ÷ t½
- [ ] **26.1.5** Linking mechanisms, rate-determining steps and rate equations; intermediates and catalysts
- [ ] **26.1.6** Effect of temperature on the rate constant
- [ ] **26.2.1** Homogeneous and heterogeneous catalysts
- [ ] **26.2.2** Heterogeneous catalysis: adsorption, weakening bonds, desorption (Fe in Haber; Pd, Pt, Rh in exhausts)
- [ ] **26.2.3** Homogeneous catalysis: NOx in SO_2 oxidation; Fe^{2+}/Fe^{3+} in I^- + $S_2O_8^{2-}$

A Level: inorganic chemistry

27 Group 2

- [ ] **27.1.1** Thermal stability of nitrates and carbonates: polarisation of the anion
- [ ] **27.1.2** Solubility of hydroxides and sulfates: lattice and hydration enthalpies

28 Chemistry of transition elements

- [ ] **28.1.1** Transition element: d-block element forming an ion with an incomplete d sub-shell
- [ ] **28.1.2** Shapes of 3dxy and $3dz^2$ orbitals
- [ ] **28.1.3** Variable oxidation states, catalysis, complex ions and coloured compounds
- [ ] **28.1.4** Variable oxidation states: 3d and 4s energies are similar
- [ ] **28.1.5** Catalysis: variable oxidation states and dative bonding
- [ ] **28.1.6** Complex formation: vacant d orbitals
- [ ] **28.2.1** Ligand reactions of Cu^{2+} and Co^{2+} with H_2O, NH_3, OH^- and Cl^-
- [ ] **28.2.2** Ligand: definition
- [ ] **28.2.3** Monodentate (H_2O, NH_3, Cl^-, CN^-), bidentate (en, $C_2O_4^{2-}$), polydentate ($EDTA^{4-}$)
- [ ] **28.2.4** Complex: definition
- [ ] **28.2.5** Linear, square planar, tetrahedral and octahedral complexes
- [ ] **28.2.6** Coordination number; formula and charge of a complex ion
- [ ] **28.2.7** Ligand exchange in Cu^{2+} and Co^{2+} complexes
- [ ] **28.2.8** Feasibility of redox reactions from E° values
- [ ] **28.2.9** Redox titrations: MnO_4^- with $C_2O_4^{2-}$ or Fe^{2+}; Cu^{2+} with I^-
- [ ] **28.2.10** Calculations for other redox systems
- [ ] **28.3.1** Degenerate and non-degenerate d orbitals
- [ ] **28.3.2** Splitting of d orbitals in octahedral and tetrahedral complexes
- [ ] **28.3.3** Colour from light absorbed when electrons move between d orbitals
- [ ] **28.3.4** Ligand affects ΔE and so the colour seen (complementary colour)
- [ ] **28.3.5** Ligand exchange changes colour (Cu^{2+}, Co^{2+})
- [ ] **28.4.1** cis/trans and optical isomers of complexes ($[Pt(NH_3)_2Cl_2]$, $[Ni(en)_3]^{2+}$ and others)

- [ ] **28.4.2** Polarity of these complexes
- [ ] **28.5.1** Stability constant Kstab
- [ ] **28.5.2** Writing Kstab expressions
- [ ] **28.5.3** Kstab calculations
- [ ] **28.5.4** Ligand exchange and large Kstab

A Level: organic chemistry and analysis

29 An introduction to A Level organic chemistry

- [ ] **29.1.1** Functional groups decide properties
- [ ] **29.1.2** Interpreting general, structural, displayed and skeletal formulas
- [ ] **29.1.3** Naming aliphatic compounds up to six carbons
- [ ] **29.1.4** Naming aromatic compounds (e.g. 3-nitrobenzoic acid)
- [ ] **29.2.1** Terms: electrophilic substitution, addition–elimination
- [ ] **29.3.1** Shape of benzene: sp^2 carbons, σ bonds, delocalised π system
- [ ] **29.4.1** Enantiomers differ only in optical rotation and biological activity
- [ ] **29.4.2** Optically active; racemic mixture
- [ ] **29.4.3** Rotation of plane-polarised light
- [ ] **29.4.4** Different biological activity, separating racemates, chiral catalysts

30 Hydrocarbons (arenes)

- [ ] **30.1.1a** Halogenation: Cl_2 or Br_2 with $AlCl_3$ or $AlBr_3$
- [ ] **30.1.1b** Nitration: concentrated HNO_3 and H_2SO_4, 25–60 °C
- [ ] **30.1.1c** Friedel–Crafts alkylation: CH_3Cl and $AlCl_3$
- [ ] **30.1.1d** Friedel–Crafts acylation: CH_3COCl and $AlCl_3$
- [ ] **30.1.1e** Side-chain oxidation: hot alkaline $KMnO_4$, then acid
- [ ] **30.1.1f** Hydrogenation to cyclohexane: H_2, Pt or Ni
- [ ] **30.1.2** Electrophilic substitution mechanism; why benzene substitutes rather than adds
- [ ] **30.1.3** Side-chain versus ring halogenation depends on conditions
- [ ] **30.1.4** Directing effects of $–NH_2$, –OH, –R, $–NO_2$, –COOH, –COR

31 Halogen compounds

- [ ] **31.1.1** Making halogenoarenes: chlorobenzene, chloromethylbenzenes
- [ ] **31.1.2** Halogenoalkanes versus halogenoarenes (chloroethane vs chlorobenzene)

32 Hydroxy compounds

- [ ] **32.1.1** Alcohols with acyl chlorides give esters
- [ ] **32.2.1** Phenol from phenylamine via a diazonium salt
- [ ] **32.2.2** Phenol with NaOH, Na, diazonium salts, dilute HNO_3 and Br_2(aq)
- [ ] **32.2.3** Why phenol is acidic
- [ ] **32.2.4** Acidity of water, phenol and ethanol
- [ ] **32.2.5** Why phenol reacts under milder conditions than benzene
- [ ] **32.2.6** –OH directs to the 2-, 4- and 6-positions
- [ ] **32.2.7** Applying this to other phenols (e.g. naphthol)

33 Carboxylic acids and derivatives

- [ ] **33.1.1** Benzoic acid from alkylbenzenes: hot alkaline $KMnO_4$, then acid
- [ ] **33.1.2** Acyl chlorides from carboxylic acids: PCl_3, PCl_5, $SOCl_2$
- [ ] **33.1.3** Oxidation of methanoic acid and ethanedioic acid
- [ ] **33.1.4** Acidity of carboxylic acids, phenols and alcohols
- [ ] **33.1.5** Acidity of chlorine-substituted carboxylic acids
- [ ] **33.2.1** Esters from alcohols or phenols and acyl chlorides
- [ ] **33.3.2** Acyl chlorides with water, alcohols, phenols, ammonia and amines
- [ ] **33.3.3** Addition–elimination mechanism
- [ ] **33.3.4** Ease of hydrolysis: acyl, alkyl and aryl chlorides

34 Nitrogen compounds

- [ ] **34.1.1** Making amines: halogenoalkanes, reducing amides and nitriles
- [ ] **34.1.2** Amines and ammonia with acyl chlorides give amides
- [ ] **34.1.3** Basicity of aqueous amines
- [ ] **34.2.1** Phenylamine: nitrate benzene, reduce with Sn/concentrated HCl, then NaOH
- [ ] **34.2.2** Phenylamine with Br_2(aq) and with HNO_2 (diazonium salts)
- [ ] **34.2.3** Basicity of ammonia, ethylamine and phenylamine
- [ ] **34.2.4** Azo coupling with phenol; azo dyes
- [ ] **34.3.1** Making amides from acyl chlorides
- [ ] **34.3.2** Hydrolysis of amides; reduction with $LiAlH_4$
- [ ] **34.3.3** Amides are much weaker bases than amines
- [ ] **34.4.1** Amino acids: zwitterions, isoelectric point
- [ ] **34.4.2** Peptide bonds: di- and tripeptides
- [ ] **34.4.3** Electrophoresis of amino acids and dipeptides at different pH

35 Polymerisation

- [ ] **35.1.1** Polyesters from diols and dicarboxylic acids (or dioyl chlorides), and from hydroxy acids
- [ ] **35.1.2** Polyamides from diamines and dicarboxylic acids, aminocarboxylic acids and amino acids
- [ ] **35.1.3** Repeat unit from monomers
- [ ] **35.1.4** Monomers from a section of polymer
- [ ] **35.2.1** Predict the type of polymerisation from the monomers
- [ ] **35.2.2** Deduce the type of polymerisation from the polymer
- [ ] **35.3.1** Poly(alkene)s are inert and hard to biodegrade
- [ ] **35.3.2** Some polymers are degraded by light
- [ ] **35.3.3** Polyesters and polyamides are biodegradable by hydrolysis

36 Organic synthesis

- [ ] **36.1.1** Identify functional groups and predict properties and reactions
- [ ] **36.1.2** Devise multi-step synthetic routes
- [ ] **36.1.3** Analyse a route: reaction types, reagents, by-products

37 Analytical techniques

- [ ] **37.1.1** Thin-layer chromatography: stationary and mobile phases, Rf, solvent front, baseline
- [ ] **37.1.2** Interpreting Rf values
- [ ] **37.1.3** Explaining differences in Rf values

- [ ] **37.2.1** Gas–liquid chromatography: stationary and mobile phases, retention time
- [ ] **37.2.2** Interpreting chromatograms; percentage composition
- [ ] **37.2.3** Explaining retention times
- [ ] **37.3.1** ^{13}C NMR: carbon environments and possible structures
- [ ] **37.3.2** Predicting the number of ^{13}C peaks
- [ ] **37.4.1** ^{1}H NMR: chemical shift, peak areas, n + 1 rule, possible structures
- [ ] **37.4.2** Predicting chemical shifts and splitting patterns
- [ ] **37.4.3** TMS as the reference standard
- [ ] **37.4.4** Deuterated solvents such as $CDCl_3$
- [ ] **37.4.5** Identifying O–H and N–H protons by D_2O exchange