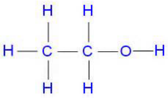
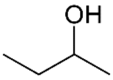
4.1.1 Basic organic chemistry

(a) application of IUPAC rules of nomenclature for systematically naming organic compounds		🟥	🟨	🟩	
(b) interpretation and use of the terms: **(i)** *general formula* (the simplest algebraic formula of a member of a homologous series) e.g. for an alkane: C_nH_{2n+2} **(ii)** *structural formula* (the minimal detail that shows the arrangement of atoms in a molecule) e.g. for butane: $CH_3CH_2CH_2CH_3$ or $CH_3(CH_2)_2CH_3$ **(iii)** *displayed formula* (the relative positioning of atoms and the bonds between them) e.g. for ethanol:  **(iv)** *skeletal formula* (the simplified organic formula, shown by removing hydrogen atoms from alkyl chains, leaving just a carbon skeleton and associated functional groups) e.g. for butan-2-ol: 		🟥	🟨	🟩	
(c) interpretation and use of the terms: **(i)** *homologous series* (a series of organic compounds having the same functional group but with each successive member differing by CH_2) **(ii)** *functional group* (a group of atoms responsible for the characteristic reactions of a compound) **(iii)** *alkyl group* (of formula C_nH_{2n+1}) **(iv)** *aliphatic* (a compound containing carbon and hydrogen joined together in straight chains, branched chains or non-aromatic rings) **(v)** *alicyclic* (an aliphatic compound arranged in non-aromatic rings with or without side chains) *aromatic* (a compound containing a benzene ring) **(vii)** *saturated* (single carbon–carbon bonds only) and *unsaturated* (the presence of multiple carbon–carbon bonds, including C=C, CC /and aromatic rings)		🟥	🟨	🟩	
(d) use of the general formula of a homologous series to predict the formula of any member of the series		🟥	🟨	🟩	
(e) explanation of the term *structural isomers* (compounds with the same molecular formula but different structural formulae) and determination of possible structural formulae of an organic molecule, given its molecular formula		🟥	🟨	🟩	
(f) the different types of covalent bond fission: **(i)** homolytic fission (in terms of each bonding atom receiving one electron from the bonded pair, forming two radicals) i) **(ii)** heterolytic fission (in terms of one bonding atom receiving both electrons from the bonded pair)		🟥	🟨	🟩	
(g) the term *radical* (a species with an unpaired electron) and use of 'dots' to represent species that are radicals in mechanisms		🟥	🟨	🟩	
(h) a 'curly arrow' described as the movement of an electron pair, showing either heterolytic fission or formation of a covalent bond		🟥	🟨	🟩	
(i) reaction mechanisms, using diagrams, to show clearly the movement of an electron pair with 'curly arrows' and relevant dipoles.		🟥	🟨	🟩	

4.1.2 Alkanes

(a) alkanes as saturated hydrocarbons containing single C–C and C–H bonds as σ-bonds (overlap of orbitals directly between the bonding atoms); free rotation of the σ-bond		🟥	🟨	🟩	
(b) explanation of the tetrahedral shape and bond angle around each carbon atom in alkanes in terms of electron pair repulsion **(see also 2.2.2 g–h)**		🟥	🟨	🟩	

(c) explanation of the variations in boiling points of alkanes with different carbon-chain length and branching, in terms of induced dipole–dipole interactions (London forces) **(see also 2.2.2 k)**		🟥	🟨	🟩	
(d) the low reactivity of alkanes with many reagents in terms of the high bond enthalpy and very low polarity of the σ-bonds present **(see also 2.2.2 j)**		🟥	🟨	🟩	
(e) complete combustion of alkanes, as used in fuels, and the incomplete combustion of alkane fuels in a limited supply of oxygen with the resulting potential dangers from CO		🟥	🟨	🟩	
(f) the reaction of alkanes with chlorine and bromine by radical substitution using ultraviolet radiation, including a mechanism involving homolytic fission and radical reactions in terms of initiation, propagation and termination **(see also 4.1.1 f–g)**		🟥	🟨	🟩	
(g) the limitations of radical substitution in synthesis by the formation of a mixture of organic products, in terms of further substitution and reactions at different positions in a carbon chain.		🟥	🟨	🟩	

4.1.3 Alkenes

(a) alkenes as unsaturated hydrocarbons containing a C=C bond comprising a π-bond (sideways overlap of adjacent p-orbitals above and below the bonding C atoms) and a σ-bond (overlap of orbitals directly between the bonding atoms) **(see also 4.1.2 a)**; restricted rotation of the π-bond		🟥	🟨	🟩	
(b) explanation of the trigonal planar shape and bond angle around each carbon in the C=C of alkenes in terms of electron pair repulsion **(see also 2.2.2 g–h, 4.1.2 b)**		🟥	🟨	🟩	
(c) **(i)** explanation of the terms: • *stereoisomers* (compounds with the same structural formula but with a different arrangement in space) • *E*/*Z isomerism* (an example of stereoisomerism, in terms of restricted rotation about a double bond and the requirement for two different groups to be attached to each carbon atom of the C=C group) • *cis–trans isomerism* (a special case of *E*/*Z* isomerism in which two of the substituent groups attached to each carbon atom of the C=C group are the same) **(ii)** use of Cahn–Ingold–Prelog (CIP) priority rules to identify the *E* and *Z* stereoisomers		🟥	🟨	🟩	
(d) determination of possible *E*/*Z* or *cis–trans* stereoisomers of an organic molecule, given its structural formula		🟥	🟨	🟩	
(e) the reactivity of alkenes in terms of the relatively low bond enthalpy of the π-bond		🟥	🟨	🟩	
(f) addition reactions of alkenes with: **(i)** hydrogen in the presence of a suitable catalyst, e.g. Ni, to form alkanes **(ii)** halogens to form dihaloalkanes, including the use of bromine to detect the presence of a double C=C bond as a test for unsaturation in a carbon chain **(iii)** hydrogen halides to form haloalkanes **(iv)** steam in the presence of an acid catalyst, e.g. H_3PO_4, to form alcohols		🟥	🟨	🟩	
(g) definition and use of the term *electrophile* (an electron pair acceptor)		🟥	🟨	🟩	
(h) the mechanism of electrophilic addition in alkenes by heterolytic fission **(see also 4.1.1 h–i)**		🟥	🟨	🟩	
(i) use of Markownikoff's rule to predict formation of a major organic product in addition reactions of H–X to unsymmetrical alkenes, e.g. H–Br to propene, in terms of the relative stabilities of carbocation intermediates in the mechanism		🟥	🟨	🟩	
(j) addition polymerisation of alkenes and substituted alkenes, including: **(i)** the repeat unit of an addition polymer deduced from a given monomer **(ii)** identification of the monomer that would produce a given section of an addition polymer		🟥	🟨	🟩	
(k) the benefits for sustainability of processing waste polymers by: **(i)** combustion for energy production **(ii)** use as an organic feedstock for the production of plastics and other organic chemicals **(iii)** removal of toxic waste products, e.g. removal of HC*l* formed during disposal by combustion of halogenated plastics (e.g. PVC)		🟥	🟨	🟩	