

## Chemistry A Level (9746)

Topic	Content	Learning Outcomes:	Suggested Website Resource	Remarks
1. Atoms, Molecules and Stoichiometry	<ul style="list-style-type: none"> <li>Relative masses of atoms and molecules</li> <li>The mole, the Avogadro constant</li> <li>The calculation of empirical and molecular formulae</li> <li>Reacting masses and volumes (of solutions and gases)</li> </ul>	(a) define the terms relative atomic, isotopic, molecular and formula mass, based on the $^{12}\text{C}$ scale		
		(b) define the term mole in terms of the Avogadro constant	<a href="http://www.wwnorton.com/chemistry/overview/ch4.htm">http://www.wwnorton.com/chemistry/overview/ch4.htm</a>	Animated tutorial and exercise.
		(c) calculate the relative atomic mass of an element given the relative abundances of its isotopes		
		(d) define the terms empirical and molecular formula		
		(e) calculate empirical and molecular formulae using		

		combustion data or composition by mass		
		(f) write and/or construct balanced equations	<a href="http://www.wwnorton.com/chemistry/overview/ch4.htm">http://www.wwnorton.com/chemistry/overview/ch4.htm</a>	Animated tutorial.
		(g) perform calculations, including use of the mole concept, involving: (i) reacting masses (from formulae and equations) (ii) volumes of gases (e.g. in the burning of hydrocarbons) (iii) volumes and concentrations of solutions		
		(h) deduce stoichiometric relationships from calculations such as those in (g)		
2. Atomic Structure	<ul style="list-style-type: none"> <li>The nucleus of the atom: neutrons and protons, isotopes, proton and nucleon</li> </ul>	(a) identify and describe protons, neutrons and electrons in terms of their relative charges and relative masses	<a href="http://www.chemguide.co.uk/atoms/properties/gcse.html#top">http://www.chemguide.co.uk/atoms/properties/gcse.html#top</a>	Notes.

	<p>numbers</p> <ul style="list-style-type: none"> <li>● Electrons: electronic energy levels, ionisation energies, atomic orbitals, extranuclear structure</li> </ul>			
		(b) deduce the behaviour of beams of protons, neutrons and electrons in both electric and magnetic fields	<a href="http://lectureonline.cl.msu.edu/%7Emmp/kap21/cd533capp.htm">http://lectureonline.cl.msu.edu/%7Emmp/kap21/cd533capp.htm</a>	Java applet simulation.
		(c) describe the distribution of mass and charges within an atom		
		(d) deduce the numbers of protons, neutrons and electrons present in both atoms and ions given proton and nucleon numbers (and charge)		
		(e) (i) describe the contribution of protons and neutrons to atomic nuclei in terms		

		<p>of proton number and nucleon number</p> <p>(ii) distinguish between isotopes on the basis of different numbers of neutrons present</p>		
		<p>(f) describe the number and relative energies of the s, p and d orbitals for the principal quantum numbers 1, 2 and 3 and also the 4s and 4p orbitals</p>	<p><a href="http://www.colby.edu/chemistry/OChem/DEMOS/Orbitals.html">http://www.colby.edu/chemistry/OChem/DEMOS/Orbitals.html</a></p> <p><a href="http://chemmovies.unl.edu/ChemAnime/ECOFNFIG/ECONFIG.html">http://chemmovies.unl.edu/ChemAnime/ECOFNFIG/ECONFIG.html</a></p>	<p>Animated slide show</p> <p>Energy level simulation.</p>
		<p>(g) describe the shapes of s and p orbitals</p>	<p><a href="http://winter.group.shef.ac.uk/orbitron/">http://winter.group.shef.ac.uk/orbitron/</a></p>	<p>3D visualisations.</p>
		<p>(h) state the electronic configuration of atoms and ions given the proton number (and charge)</p>	<p><a href="http://lectureonline.cl.msu.edu/~mmp/period/electron.htm">http://lectureonline.cl.msu.edu/~mmp/period/electron.htm</a></p>	<p>Java applet showing electronic configuration.</p>
		<p>(i) (i) explain the factors influencing the ionisation energies of elements (see the Data Booklet)</p> <p>(ii) explain the trends in</p>		

		ionisation energies across a Period and down a Group of the Periodic Table (see also Section 9)		
		(j) deduce the electronic configurations of elements from successive ionisation energy data		
		(k) interpret successive ionisation energy data of an element in terms of the position of that element within the Periodic Table		
3. Chemical Bonding	<p>Ionic (electrovalent) bonding</p> <p>Covalent bonding and co-ordinate (dative covalent) bonding</p> <p>(i) The shapes of simple molecules</p> <p>(ii) Bond energies, bond lengths and bond polarities</p>	(a) describe ionic (electrovalent) bonding, as in sodium chloride and magnesium oxide, including the use of 'dot-and-cross' diagrams	<a href="http://www.chemguide.co.uk/atoms/bonding/ionic.html">http://www.chemguide.co.uk/atoms/bonding/ionic.html</a>	Notes.

	<p>Intermolecular forces, including hydrogen bonding</p> <p>Metallic bonding</p> <p>Bonding and physical properties</p> <p>The solid state</p>			
		<p>(b) describe, including the use of 'dot-and-cross' diagrams,</p> <p>(i) covalent bonding, as in hydrogen; oxygen; nitrogen; chlorine; hydrogen chloride; carbon dioxide; methane; ethene</p> <p>(ii) co-ordinate (dative covalent) bonding, as in formation of the ammonium ion and in the <math>Al_2Cl_6</math> molecule.</p>	<p><a href="http://www.chemguide.co.uk/atoms/bonding/covalent.html">http://www.chemguide.co.uk/atoms/bonding/covalent.html</a></p> <p><a href="http://www.chemguide.co.uk/atoms/bonding/covalent.html">http://www.chemguide.co.uk/atoms/bonding/covalent.html</a></p>	<p>Notes.</p> <p>Notes.</p>
		<p>(c) explain the shapes of, and bond angles in, molecules such as <math>BF_3</math> (trigonal planar); <math>CO_2</math> (linear); <math>CH_4</math></p>	<p><a href="http://www.chem1.com/acad/webtext/chembond/cb05.html">http://www.chem1.com/acad/webtext/chembond/cb05.html</a></p> <p><a href="http://www.chem.purdue.edu/gchelp/vsepr/">http://www.chem.purdue.edu/gchelp/vsepr/</a></p>	<p>Notes.</p> <p>3D models</p>

		(tetrahedral); NH <sub>3</sub> (trigonal pyramidal); H <sub>2</sub> O (non-linear); SF <sub>6</sub> (octahedral) by using the Valence Shell Electron Pair Repulsion theory	<a href="http://www.public.asu.edu/~jpbirk/">http://www.public.asu.edu/~jpbirk/</a> <a href="http://bcs.whfreeman.com/chemicalprinciples3e/content/simulations/molshape.htm">http://bcs.whfreeman.com/chemicalprinciples3e/content/simulations/molshape.htm</a>	(require the <i>Chime</i> plugin)  On-line exercise on molecular shapes.
		(d) describe covalent bonding in terms of orbital overlap, giving $\sigma$ and $\pi$ bonds (see also Section 10.1)		
		(e) predict the shapes of, and bond angles in, molecules analogous to those specified in (c)		
		(f) describe hydrogen bonding, using ammonia and water as examples of molecules containing -NH and -OH groups	<a href="http://www.wwnorton.com/chemistry/overview/ch9.htm">http://www.wwnorton.com/chemistry/overview/ch9.htm</a> <a href="http://programs.northlandcollege.edu/biology/Biology1111/animations/hydrogenbonds.html">http://programs.northlandcollege.edu/biology/Biology1111/animations/hydrogenbonds.html</a>	Tutorial with 3D models.  Animation – hydrogen bonding in water.
		(g) explain the terms bond energy, bond length and bond polarity and use them to compare the reactivities of covalent bonds		

		(i) describe metallic bonding in terms of a lattice of positive ions surrounded by mobile electrons		
		(j) describe, interpret and/or predict the effect of different types of bonding (ionic bonding; covalent bonding; hydrogen bonding; other intermolecular interactions; metallic bonding) on the physical properties of substances		
		(k) deduce the type of bonding present from given information		
		(l) show understanding of chemical reactions in terms of energy transfers associated with the breaking and making of chemical bonds		
		(m) describe, in simple terms, the		

		<p>lattice structure of a crystalline solid which is:</p> <p>(i) ionic, as in sodium chloride, magnesium oxide</p> <p>(ii) simple molecular, as in iodine</p> <p>(iii) giant molecular, as in graphite; diamond</p> <p>(iv) hydrogen-bonded, as in ice</p> <p>(v) metallic, as in copper [the concept of the 'unit cell' is not required]</p>		
		<p>(n) outline the importance of hydrogen bonding to the physical properties of substances, including ice and water</p>		
		<p>(o) suggest from quoted physical data the type of structure and bonding present in a substance</p>		
		<p>(p) recognise that materials are a</p>		

		finite resource and the importance of recycling processes		
4. The gaseous State	Ideal gas behaviour and deviations from it $pV = nRT$ and its use in determining a value for $M_r$	(a) state the basic assumptions of the kinetic theory as applied to an ideal gas	<a href="http://www.chm.davidson.edu/ChemistryApplets/KineticMolecularTheory/BasicConcepts.htm">http://www.chm.davidson.edu/ChemistryApplets/KineticMolecularTheory/BasicConcepts.htm</a>	Notes with Java simulation.
		(b) explain qualitatively in terms of intermolecular forces and molecular size: (i) the conditions necessary for a gas to approach ideal behaviour (ii) the limitations of ideality at very high pressures and very low temperatures	<a href="http://www.chem.ufl.edu/~itl/2045/lectures/lecture_e.html">http://www.chem.ufl.edu/~itl/2045/lectures/lecture_e.html</a> <a href="http://library.thinkquest.org/C006669/data/Chem/gases/vanderwaals.html">http://library.thinkquest.org/C006669/data/Chem/gases/vanderwaals.html</a> <a href="http://www.wwnorton.com/chemistry/overview/ch8.htm">http://www.wwnorton.com/chemistry/overview/ch8.htm</a>	Notes. Notes. Animated tutorial.
		(c) state and use the general gas equation $pV = nRT$ in calculations, including the determination of $M_r$	<a href="http://jersey.uoregon.edu/Piston/index.html">http://jersey.uoregon.edu/Piston/index.html</a>	Simulated experiment.

<p>5. Chemical Energetics</p>	<p>Enthalpy changes: <math>\Delta H</math>, of formation; combustion; hydration; solution; neutralisation; atomisation; bond energy; lattice energy; electron affinity Hess' Law, including Born-Haber cycles Entropy and Free Energy</p>	<p>(a) explain that some chemical reactions are accompanied by energy changes, principally in the form of heat energy; the energy changes can be exothermic (<math>\Delta H</math>, negative) or endothermic (<math>\Delta H</math>, positive)</p>		
		<p>(b) explain and use the terms: (i) enthalpy change of reaction and standard conditions, with particular reference to: formation; combustion; hydration; solution; neutralisation; atomisation (ii) bond energy (<math>\Delta H</math> positive, i.e. bond breaking) (iii) lattice energy (<math>\Delta H</math></p>	<p><a href="http://chemmovies.unl.edu/ChemAnime/LATH20ED/LATH20ED.html">http://chemmovies.unl.edu/ChemAnime/LATH20ED/LATH20ED.html</a></p>	<p>Animated tutorial.</p>

		negative, i.e. gaseous ions to solid lattice)		
		(c) calculate enthalpy changes from appropriate experimental results, including the use of the relationship $\text{enthalpy change} = mc\Delta T$	<a href="http://www.chm.davidson.edu/ChemistryApplets/calorimetry/HeatOFNeutralization.html">http://www.chm.davidson.edu/ChemistryApplets/calorimetry/HeatOFNeutralization.html</a> <a href="http://www.chm.davidson.edu/ChemistryApplets/calorimetry/HeatOFCombustionOfMethane.html">http://www.chm.davidson.edu/ChemistryApplets/calorimetry/HeatOFCombustionOfMethane.html</a>	Java simulations.
		(d) explain, in qualitative terms, the effect of ionic charge and of ionic radius on the numerical magnitude of a lattice energy	<a href="http://chemmovies.unl.edu/ChemAnime/IONSIZED/IONSIZED.html">http://chemmovies.unl.edu/ChemAnime/IONSIZED/IONSIZED.html</a>	Animation.
		(e) apply Hess' Law to construct simple energy cycles, e.g. Born-Haber cycle, and carry out calculations involving such cycles and relevant energy terms (including ionisation energy and electron affinity), with particular reference to: (i) determining enthalpy changes that cannot be	<a href="http://www.dartmouth.edu/%7echemlab/info/resources/deltah/deltah.html">http://www.dartmouth.edu/%7echemlab/info/resources/deltah/deltah.html</a> <a href="http://www.wwnorton.com/chemistry/overview/ch11.htm">http://www.wwnorton.com/chemistry/overview/ch11.htm</a>	Energy level diagram Java simulation.  Animated tutorial.

		<p>found by direct experiment, e.g. an enthalpy change of formation from enthalpy changes of combustion</p> <p>(ii) the formation of a simple ionic solid and of its aqueous solution</p> <p>(iii) average bond energies</p>		
		(f) construct and interpret a reaction pathway diagram, in terms of the enthalpy change of the reaction and of the activation energy	<a href="http://bcs.whfreeman.com/chemicalprinciples3e/content/simulations/gc14ax02.htm">http://bcs.whfreeman.com/chemicalprinciples3e/content/simulations/gc14ax02.htm</a>	<p>On-line exercise on reaction pathway diagram.</p> <p>Animation with narration.</p>
		(g) explain and use the term entropy		
		(h) discuss the effects on the entropy of a chemical system by the following: <ul style="list-style-type: none"> <li>(i) change in temperature</li> <li>(ii) change in phase</li> <li>(iii) change in the number of particles (especially for</li> </ul>	<a href="http://www.wwnorton.com/chemistry/overview/ch13.htm">http://www.wwnorton.com/chemistry/overview/ch13.htm</a>	Animated tutorial.

		gaseous systems) (iv) mixing of particles [quantitative treatment is not required]		
		(i) predict whether the entropy change for a given process or reaction is positive or negative		
		(j) define standard Gibbs free energy change of reaction by means of the equation $\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$		
		(k) calculate $\Delta G$ for a reaction using the equation $\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$ [the calculation of standard entropy change, $\Delta S^\ominus$ , for a reaction using standard entropies, $S^\ominus$ , is not required]	<a href="http://www.wwnorton.com/chemistry/overview/ch13.htm">http://www.wwnorton.com/chemistry/overview/ch13.htm</a>  <a href="http://mc2.cchem.berkeley.edu/Java/Gibbs/Gibbs.html">http://mc2.cchem.berkeley.edu/Java/Gibbs/Gibbs.html</a>	Animated tutorial.  Java applet showing relationship between $\Delta G$ , $\Delta H^\ominus$ , $\Delta S^\ominus$ and T.
		(l) state whether a reaction or process will be spontaneous by using the sign of $\Delta G^\ominus$		

		(m) predict the effect of temperature change on the spontaneity of a reaction, given standard enthalpy and entropy changes		
6. Electrochemistry	<ul style="list-style-type: none"> <li>● Redox processes: electron transfer and changes in oxidation number (oxidation state)</li> <li>● Electrode potentials <ul style="list-style-type: none"> <li>(i) Standard electrode (redox) potentials, <math>E</math>; the redox series</li> <li>(ii) Standard cell potentials, <math>E_{cell}</math>, and their uses</li> <li>(iii) Batteries and fuel cells</li> </ul> </li> <li>● Electrolysis <ul style="list-style-type: none"> <li>(i) Factors affecting the amount of substance liberated during electrolysis</li> <li>(ii) The Faraday</li> </ul> </li> </ul>	(a) describe and explain redox processes in terms of electron transfer and/or of changes in oxidation number (oxidation state)	<a href="http://www.chemguide.co.uk/inorganic/redoxmenu.html#top%20">http://www.chemguide.co.uk/inorganic/redoxmenu.html#top%20</a>	Notes.  Animation of an electrochemical cell.

	<p>constant; the Avogadro constant; their relationship</p> <p>(iii) Industrial uses of electrolysis</p>			
		<p>(b) define the terms:</p> <p>(i) standard electrode (redox) potential</p> <p>(ii) standard cell potential</p>		
		<p>(c) describe the standard hydrogen electrode</p>		
		<p>(d) describe methods used to measure the standard electrode potentials of:</p> <p>(i) metals or non-metals in contact with their ions in aqueous solution</p> <p>(ii) ions of the same element in different oxidation states</p>	<p><a href="http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/electroChem/voltaicCell20.html">http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/electroChem/voltaicCell20.html</a></p> <p><a href="http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/SHEZnV7.html">http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/SHEZnV7.html</a></p> <p><a href="http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/SHECu.html">http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/SHECu.html</a></p>	<p>Simulation.</p> <p>Simulation.</p> <p>Simulation.</p>

		(e) calculate a standard cell potential by combining two standard electrode potentials	<a href="http://www.wwnorton.com/chemistry/tutorials/ch17.htm">http://www.wwnorton.com/chemistry/tutorials/ch17.htm</a>	Animated tutorial.
		(f) use standard cell potentials to: (i) explain/deduce the direction of electron flow from a simple cell (ii) predict the feasibility of a reaction		
		(g) understand the limitations in the use of standard cell potentials to predict the feasibility of a reaction		
		(h) construct redox equations using the relevant half-equations (see also Section 9.4)		
		(i) predict qualitatively how the value of an electrode potential varies with the concentration of the aqueous ion	<a href="http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/electroChem/voltaicCellEMF.html">http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/electroChem/voltaicCellEMF.html</a>	Simulation.

		(j) state the possible advantages of developing other types of cell, e.g. the H <sub>2</sub> /O <sub>2</sub> fuel cell and improved batteries (as in electric vehicles) in terms of smaller size, lower mass and higher voltage	<a href="http://www.wwnorton.com/chemistry/tutorials/ch17.htm">http://www.wwnorton.com/chemistry/tutorials/ch17.htm</a>	Animated tutorial.
		(k) state the relationship, $F = Le$ , between the Faraday constant, the Avogadro constant and the charge on the electron		
		(l) predict the identity of the substance liberated during electrolysis from the state of electrolyte (molten or aqueous), position in the redox series (electrode potential) and concentration		
		(m) calculate: (i) the quantity of charge passed during electrolysis	<a href="http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/electroChem/electrolysis10.html">http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/electroChem/electrolysis10.html</a>	Simulation.

		(ii) the mass and/or volume of substance liberated during electrolysis, including those in the electrolysis of $\text{H}_2\text{SO}_4(\text{aq})$ ; $\text{Na}_2\text{SO}_4(\text{aq})$		
		(n) explain, in terms of the electrode reactions, the industrial processes of: (i) the anodising of aluminium (ii) the electrolytic purification of copper [technical details are not required]		
7. Equilibria	<ul style="list-style-type: none"> <li>● Chemical equilibria: reversible reactions; dynamic equilibrium <ul style="list-style-type: none"> <li>(i) Factors affecting chemical equilibria</li> <li>(ii) Equilibrium constants</li> <li>(iii) The Haber process</li> </ul> </li> <li>● Ionic equilibria <ul style="list-style-type: none"> <li>(i) Bronsted-Lowry</li> </ul> </li> </ul>	(a) explain, in terms of rates of the forward and reverse reactions, what is meant by a reversible reaction and dynamic equilibrium	<a href="http://www.chemguide.co.uk/physical/equilibria/introduction.html#top">http://www.chemguide.co.uk/physical/equilibria/introduction.html#top</a>	Notes.

	<p>theory of acids and bases</p> <p>(ii) Acid dissociation constants, <math>K_a</math> and the use of <math>pK_a</math></p> <p>(iii) Base dissociation constants, <math>K_b</math> and the use of <math>pK_b</math></p> <p>(iv) The ionic product of water, <math>K_w</math></p> <p>(v) pH: choice of pH indicators</p> <p>(vi) Buffer solutions</p> <p>(vii) Solubility product; the common ion effect</p>			
		<p>(b) state Le Chatelier's Principle and apply it to deduce qualitatively (from appropriate information) the effects of changes in concentration, pressure or temperature, on a system at equilibrium</p>	<p><a href="http://www.chemguide.co.uk/physical/equilibria/lechatelier.html#top">http://www.chemguide.co.uk/physical/equilibria/lechatelier.html#top</a></p> <p><a href="http://www.chm.davidson.edu/ChemistryApplets/equilibria/LeChatelier.html">http://www.chm.davidson.edu/ChemistryApplets/equilibria/LeChatelier.html</a></p> <p><a href="http://www.chm.davidson.edu/ChemistryApplets/equilibria/Temperature.html">http://www.chm.davidson.edu/ChemistryApplets/equilibria/Temperature.html</a></p> <p><a href="http://www.chm.davidson.edu/ChemistryApplets/equilibria/Temperature.html">http://www.chm.davidson.edu/ChemistryApplets/equilibria/Temperature.html</a></p>	<p>Notes.</p> <p>Notes.</p> <p>Simulation.</p> <p>Simulation.</p>

			<a href="http://www.chemguide.co.uk/physical/equilibria/Volume.html">ts/equilibria/Volume.html</a>	
		(c) deduce whether changes in concentration, pressure or temperature or the presence of a catalyst affect the value of the equilibrium constant for a reaction	<a href="http://www.chemguide.co.uk/physical/equilibria/change.html#top">http://www.chemguide.co.uk/physical/equilibria/change.html#top</a>	Notes.
		(d) deduce expressions for equilibrium constants in terms of concentrations, $K_c$ , and partial pressures, $K_p$ [treatment of the relationship between $K_p$ and $K_c$ is not required]	<a href="http://www.chemguide.co.uk/physical/equilibria/kc.html#top">http://www.chemguide.co.uk/physical/equilibria/kc.html#top</a> <a href="http://www.chemguide.co.uk/physical/equilibria/kp.html#top">http://www.chemguide.co.uk/physical/equilibria/kp.html#top</a> <a href="http://www.chm.davidson.edu/ChemistryApplets/equilibria/BasicConcepts.html">http://www.chm.davidson.edu/ChemistryApplets/equilibria/BasicConcepts.html</a> <a href="http://www.wwnorton.com/chemistry/overview/ch15.htm">http://www.wwnorton.com/chemistry/overview/ch15.htm</a>	Notes.  Notes.  Simulation.  Animated tutorial.
		(e) calculate the values of equilibrium constants in terms of concentrations or partial pressures from appropriate		

		data		
		(f) calculate the quantities present at equilibrium, given appropriate data (such calculations will not require the solving of quadratic equations)	<a href="http://www.wwnorton.com/chemistry/overview/ch14.htm">http://www.wwnorton.com/chemistry/overview/ch14.htm</a>	Animated tutorial.
		(g) describe and explain the conditions used in the Haber process, as an example of the importance of an understanding of chemical equilibrium in the chemical industry	<a href="http://www.chemguide.co.uk/physical/equilibria/haber.html#top">http://www.chemguide.co.uk/physical/equilibria/haber.html#top</a>	Notes.
		(h) show understanding of, and apply the Bronsted-Lowry theory of acids and bases, including the concept of conjugate acids and conjugate bases	<a href="http://www.chemguide.co.uk/physical/acidbase/equilibria/theories.html#top">http://www.chemguide.co.uk/physical/acidbase/equilibria/theories.html#top</a>  <a href="http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/NH3eqtg.html">http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/NH3eqtg.html</a>	Notes.  Animation.
		(i) explain qualitatively the differences in behaviour between strong and weak	<a href="http://www.chemguide.co.uk/physical/acidbase/equilibria/theories.html#top">http://www.chemguide.co.uk/physical/acidbase/equilibria/theories.html#top</a>	Notes.

		acids and bases in terms of the extent of dissociation	<a href="http://www.chemguide.co.uk/physical/acidbaseeqia/bases.html#top">http://www.chemguide.co.uk/physical/acidbaseeqia/bases.html#top</a>	Notes.
		(j) explain the terms pH; $K_a$ ; $pK_a$ ; $K_b$ ; $pK_b$ ; $K_w$ and apply them in calculations, including the relationship $K_w = K_a K_b$	<a href="http://www.chemguide.co.uk/physical/acidbaseeqia/kw.html#top">http://www.chemguide.co.uk/physical/acidbaseeqia/kw.html#top</a>	Notes.
		(k) calculate $[H^+(aq)]$ and pH values for strong acids, weak monobasic (monoprotic) acids, strong bases, and weak monoacidic bases	<a href="http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/acidbasepH/ph_meter.html">http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/acidbasepH/ph_meter.html</a>	pH meter simulation.
		(l) explain the choice of suitable indicators for acid-base titrations, given appropriate data	<a href="http://www.chemguide.co.uk/physical/acidbaseeqia/indicators.html#top">http://www.chemguide.co.uk/physical/acidbaseeqia/indicators.html#top</a>	Notes.
		(m) describe the changes in pH during acid-base titrations and explain these changes in terms of the strengths of the acids and bases	<a href="http://www.chemguide.co.uk/physical/acidbaseeqia/phcurves.html#top">http://www.chemguide.co.uk/physical/acidbaseeqia/phcurves.html#top</a>  <a href="http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/stoichiometry/a_b_phtitr.html">http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/stoichiometry/a_b_phtitr.html</a>	Notes.  Titration simulation.

			<a href="http://www.chem.uoa.gr/applets/AppletTitration/Appl_Titration2.html">http://www.chem.uoa.gr/applets/AppletTitration/Appl_Titration2.html</a>  <a href="http://www.wellesley.edu/Chemistry/chem120/titrate1a.xls">http://www.wellesley.edu/Chemistry/chem120/titrate1a.xls</a>	<p>Titration simulation.</p> <p>Titration simulation (MS Excel)</p>
		<p>(n) (i) explain how buffer solutions control pH</p> <p>(ii) describe and explain their uses, including the role of <math>\text{H}_2\text{CO}_3/\text{HCO}_3^-</math> in controlling pH in blood</p>	<a href="http://www.chemguide.co.uk/physical/acidbaseeqia/buffers.html#top">http://www.chemguide.co.uk/physical/acidbaseeqia/buffers.html#top</a>  <a href="http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/HOAcbuffer.html">http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/HOAcbuffer.html</a>	<p>Notes.</p> <p>Animated tutorial.</p>
		<p>(o) calculate the pH of buffer solutions, given appropriate data</p>	<a href="http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/acidbasepH/ph_buffer.html">http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/acidbasepH/ph_buffer.html</a>	<p>Buffer solution simulation.</p>
		<p>(p) show understanding of, and apply, the concept of solubility product, <math>K_{sp}</math></p>		
		<p>(q) calculate <math>K_{sp}</math> from concentrations and vice versa</p>		
		<p>(r) show understanding of the</p>		

		common ion effect		
8. Reaction Kinetics	<ul style="list-style-type: none"> <li>● Simple rate equations; orders of reaction; rate constants</li> <li>● Concept of activation energy</li> <li>● Effect of concentration, temperature, and catalysts on reaction rate</li> <li>● Homogeneous and heterogeneous catalysis</li> <li>● Enzymes as biological catalysts</li> </ul>	(a) explain and use the terms: rate of reaction; rate equation; order of reaction; rate constant; half-life of a reaction; rate-determining step; activation energy; catalysis	<a href="http://www.chm.davidson.edu/ChemistryApple/kinetics/ReactionRates.html">http://www.chm.davidson.edu/ChemistryApple/kinetics/ReactionRates.html</a>	Simulation.
		(b) construct and use rate equations of the form $\text{rate} = k[\text{A}]^m[\text{B}]^n$ (limited to simple cases of single-step reactions and of multi-step processes with a rate-determining step, for which m and n are 0, 1 or	<a href="http://www.chm.davidson.edu/ChemistryApple/kinetics/DifferentialRateLaws.html">http://www.chm.davidson.edu/ChemistryApple/kinetics/DifferentialRateLaws.html</a>  <a href="http://www.chm.davidson.edu/ChemistryApple/kinetics/Half-life.html">http://www.chm.davidson.edu/ChemistryApple/kinetics/Half-life.html</a>  <a href="http://www.chm.davidson.edu/ChemistryApple">http://www.chm.davidson.edu/ChemistryApple</a>	Simulation.  Simulation.  Simulation.

		<p>2), including:</p> <p>(i) deducing the order of a reaction by the initial rates method</p> <p>(ii) justifying, for zero- and first-order reactions, the order of reaction from concentration-time graphs</p> <p>(iii) verifying that a suggested reaction mechanism is consistent with the observed kinetics</p> <p>(iv) predicting the order that would result from a given reaction mechanism</p> <p>(v) calculating an initial rate using concentration data [integrated forms of rate equations are <b>not</b> required]</p>	<p><a href="http://www.wwnorton.com/chemistry/overview/ch14.htm">ts/kinetics/MethodOfInitialRates.html</a></p> <p><a href="http://www.wwnorton.com/chemistry/overview/ch14.htm">http://www.wwnorton.com/chemistry/overview/ch14.htm</a></p> <p><a href="http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/kinetics2/kinetics.html">http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/kinetics2/kinetics.html</a></p>	<p>Animated tutorial.</p> <p>Simulation on initial rate method.</p>
		<p>(c) (i) show understanding that the half-life of a first-order reaction is independent of concentration</p> <p>(ii) use the half-life of a first-</p>		

		order reaction in calculations		
		(d) calculate a rate constant using the initial rates method		
		(e) devise a suitable experimental technique for studying the rate of a reaction, from given information		
		(f) explain qualitatively, in terms of collisions, the effect of concentration changes on the rate of a reaction		
		(g) show understanding, including reference to the Boltzmann distribution, of what is meant by the term activation energy	<a href="http://www.chemguide.co.uk/physical/basicrates/introduction.html#top">http://www.chemguide.co.uk/physical/basicrates/introduction.html#top</a>	Notes.
		(h) explain qualitatively, in terms both of the Boltzmann distribution and of collision frequency, the effect of temperature change on a rate	<a href="http://www.chm.davidson.edu/ChemistryApplets/KineticMolecularTheory/Maxwell.html">http://www.chm.davidson.edu/ChemistryApplets/KineticMolecularTheory/Maxwell.html</a>  <a href="http://www.scrolla.hw.ac.uk/talks/shock03/che">http://www.scrolla.hw.ac.uk/talks/shock03/che</a>	Distribution of molecular speed simulation.  Simulation.

		constant (and, hence, on the rate) of a reaction	<a href="http://mweb/sqa-ucles/exploratory/generic1.html">mweb/sqa-ucles/exploratory/generic1.html</a>	
		<p>(i) (i) explain that, in the presence of a catalyst, a reaction has a different mechanism, i.e. one of lower activation energy, giving a larger rate constant</p> <p>(ii) interpret this catalytic effect on a rate constant in terms of the Boltzmann distribution</p>	<a href="http://www.wwnorton.com/chemistry/overview/ch14.htm">http://www.wwnorton.com/chemistry/overview/ch14.htm</a>	Animated tutorial.
		<p>(j) outline the different modes of action of homogeneous and heterogeneous catalysis, including:</p> <p>(i) the Haber process</p> <p>(ii) the catalytic removal of oxides of nitrogen in the exhaust gases from car engines (see also Section 10.2)</p> <p>(iii) the catalytic role of atmospheric oxides of</p>		

		<p>nitrogen in the oxidation of atmospheric sulphur dioxide</p> <p>(iv) catalytic role of <math>\text{Fe}^{3+}</math> in the <math>\text{I}^-/\text{S}_2\text{O}_8^{2-}</math> reaction</p>		
		(k) describe enzymes as biological catalysts which may have specific activity		
		(l) explain the relationship between substrate concentration and the rate of an enzyme-catalysed reaction in biochemical systems	<a href="http://www.bbc.co.uk/education/asguru/biology/02biologicalmolecules/01proteins/11enzymes/03enzymes_b/index.shtml">http://www.bbc.co.uk/education/asguru/biology/02biologicalmolecules/01proteins/11enzymes/03enzymes_b/index.shtml</a>	Animated tutorial.
9 Inorganic Chemistry			<a href="http://pearl1.lanl.gov/periodic/">http://pearl1.lanl.gov/periodic/</a> <a href="http://pearl1.lanl.gov/periodic/">http://pearl1.lanl.gov/periodic/</a> <a href="http://www.chemcool.com/">http://www.chemcool.com/</a> <a href="http://chemlab.pc.maricopa.edu/periodic/periodic.html">http://chemlab.pc.maricopa.edu/periodic/periodic.html</a>	On-line periodic tables.

			<a href="http://www.chemicalelements.com/">http://www.chemicalelements.com/</a>	
9.1 The Periodic Table: Chemical Periodicity	<ul style="list-style-type: none"> <li>● Periodicity of physical properties of the elements: variation with proton number across the third Period (sodium to argon) of: <ul style="list-style-type: none"> <li>(i) atomic radius and ionic radius</li> <li>(ii) melting point</li> <li>(iii) electrical conductivity</li> <li>(iv) ionisation energy</li> </ul> </li> <li>● Periodicity of chemical properties of the elements in the third Period <ul style="list-style-type: none"> <li>(i) Reaction of the elements with oxygen and chlorine</li> <li>(ii) Variation in oxidation number of the oxides (sodium to sulphur</li> </ul> </li> </ul>	(a) describe qualitatively (and indicate the periodicity in) the variations in atomic radius, ionic radius, melting point and electrical conductivity of the elements (see the Data Booklet)	<a href="http://www.chem.uoa.gr/Applets/AppletPerTable/App_PerTable2.html">http://www.chem.uoa.gr/Applets/AppletPerTable/App_PerTable2.html</a>	Periodic table with correlation plots.

	<p>only) and of the chlorides (sodium to phosphorus only)</p> <p>(iii) Reactions of these oxides and chlorides with water</p> <p>(iv) Acid/base behaviour of these oxides and the corresponding hydroxides</p>			
		(b) explain qualitatively the variation in atomic radius and ionic radius	<a href="http://www.chemguide.co.uk/atoms/properties/atradius.html">http://www.chemguide.co.uk/atoms/properties/atradius.html</a>	Notes.
		(c) interpret the variation in melting point and in electrical conductivity in terms of the presence of simple molecular, giant molecular or metallic bonding in the elements		
		(d) explain the variation in first	<a href="http://www.chemguide.co.uk/atoms/properties/ies.html">http://www.chemguide.co.uk/atoms/properties/ies.html</a>	Notes.

		ionisation energy		
		(e) describe the reactions, if any, of the elements with oxygen (to give $\text{Na}_2\text{O}$ ; $\text{MgO}$ ; $\text{Al}_2\text{O}_3$ ; $\text{P}_4\text{O}_{10}$ ; $\text{SO}_2$ ; $\text{SO}_3$ ), and chlorine (to give $\text{NaCl}$ ; $\text{MgCl}_2$ ; $\text{AlCl}_3$ ; $\text{SiCl}_4$ ; $\text{PCl}_5$ )		
		(f) state and explain the variation in oxidation number of the oxides and chlorides		
		(g) describe the reactions of the oxides with water [treatment of peroxides and superoxides is <b>not</b> required]		
		(h) describe and explain the acid/base behaviour of oxides and hydroxides, including, where relevant, amphoteric behaviour in reaction with sodium hydroxide (only) and acids		
		(i) describe and explain the		

		reactions of the chlorides with water		
		(j) interpret the variations and trends in (f), (g), (h), and (i) in terms of bonding and electronegativity		
		(k) suggest the types of chemical bonding present in chlorides and oxides from observations of their chemical and physical properties		
		(l) predict the characteristic properties of an element in a given Group by using knowledge of chemical periodicity		
		(m) deduce the nature, possible position in the Periodic Table, and identity of unknown elements from given information of physical and chemical properties		

9.2 Group II	<ul style="list-style-type: none"> <li>Similarities and trends in the properties of the Group II metals magnesium to barium and their compounds</li> </ul>	(a) describe the reactions of the elements with oxygen and water	<a href="http://www.chemguide.co.uk/inorganic/group2/reacto2.htm">http://www.chemguide.co.uk/inorganic/group2/reacto2.htm</a>  <a href="http://www.chemguide.co.uk/inorganic/group2/reacth2o.html">http://www.chemguide.co.uk/inorganic/group2/reacth2o.html</a>	Notes.
		(b) describe the behaviour of the oxides with water		
		(c) interpret and explain qualitatively the trend in the thermal stability of the nitrates in terms of the charge density of the cation and the polarisability of the large anion	<a href="http://www.chemguide.co.uk/inorganic/group2/thermstab.html">http://www.chemguide.co.uk/inorganic/group2/thermstab.html</a>	Notes.
		(d) interpret, and make predictions from, the trends in physical and chemical properties of the elements and their compounds		
9.3 GROUP VII	<ul style="list-style-type: none"> <li>The similarities and trends in the physical</li> </ul>	(a) describe the trends in volatility and colour of		<a href="http://www.chemguide.co.uk/inorganic/group7">http://www.chemguide.co.uk/inorganic/group7</a>

	<p>and chemical properties of chlorine, bromine and iodine</p> <p>(i) Characteristic physical properties</p> <p>(ii) The relative reactivity of the elements as oxidising agents</p> <p>(iii) Some reactions of the halide ions</p> <p>(iv) The reactions of chlorine with aqueous sodium hydroxide</p>	chlorine, bromine and iodine		<a href="#">menu.html#top</a>
		(b) analyse the volatility of the elements in terms of van der Waals' forces		
		(c) describe and deduce from E values the relative reactivity of the elements as oxidising agents		
		(e) (i) describe and explain the relative thermal stabilities		

		of the hydrides, (ii) interpret these relative stabilities in terms of bond energies		
		(f) describe and explain the reactions of halide ions with: (i) aqueous silver ions followed by aqueous ammonia, (ii) concentrated sulphuric acid	<a href="http://www.chemguide.co.uk/inorganic/group7/testing.html">http://www.chemguide.co.uk/inorganic/group7/testing.html</a>	Notes.
		(g) describe and analyse in terms of changes of oxidation number the reaction of chlorine with cold, and with hot, aqueous sodium hydroxide		
9.4 An Introduction to the Chemistry of Transition Elements	<ul style="list-style-type: none"> <li>● General physical and characteristic chemical properties of the first set of transition elements, titanium to copper</li> <li>● Colour of complexes</li> </ul>	(a) explain what is meant by a transition element, in terms of d-block elements forming one or more stable ions with incomplete d orbitals		

		(b) state the electronic configuration of a first row transition element and of its ions		
		(c) state that the atomic radii, ionic radii and first ionisation energies of the transition elements are relatively invariant		
		(d) contrast, qualitatively, the melting point; density; atomic radius; ionic radius; first ionisation energy and conductivity of the transition elements with those of calcium as a typical s-block element		
		(e) describe the tendency of transition elements to have variable oxidation states		
		(f) predict from a given	<a href="http://winter.group.shef.ac.uk/chemputer/oxid">http://winter.group.shef.ac.uk/chemputer/oxid</a>	Oxidation state

		electronic configuration, the likely oxidation states of a transition element	<a href="#">ation-number.html</a>	calculator.
		(g) describe and explain the use of $\text{Fe}^{3+}/\text{Fe}^{2+}$ , $\text{MnO}_4^-/\text{Mn}^{2+}$ and $\text{Cr}_2\text{O}_7^{2-}/\text{Cr}^{3+}$ as examples of redox systems (see also Section 6)	<a href="http://neon.chem.ox.ac.uk/vrchemistry/LiveChem/transitionmetals_content.html">http://neon.chem.ox.ac.uk/vrchemistry/LiveChem/transitionmetals_content.html</a>	Videos on the reactions of transition metal ions.
		(h) (i) explain the reactions of transition elements with ligands to form complexes, including the complexes of copper(II) ions with water and ammonia (ii) describe the formation, and state the colour of, these complexes		
		(i) predict, using $E^\ominus$ values, the likelihood of redox reactions		
		(j) explain qualitatively that ligand exchange may occur,		

		including CO/O <sub>2</sub> in haemoglobin		
		(k) explain how some transition elements and/or their compounds can act as catalysts (see also 8(j))		
		(l) explain, in terms of d orbital splitting, why transition element complexes are usually coloured		
10 Organic Chemistry				
10.1 Introductory Topics	Molecular, structural and empirical formulae Functional groups and the naming of organic compounds Characteristic organic reactions Shapes of organic molecules; $\sigma$ and $\pi$ bonds	(a) interpret, and use the nomenclature, general formulae and displayed formulae of the following classes of compound: (i) alkanes, alkenes and arenes (ii) halogenoalkanes and halogenoarenes (iii) alcohols (including primary, secondary and	<a href="http://www.chem.qmw.ac.uk/iupac/">http://www.chem.qmw.ac.uk/iupac/</a>  <a href="http://www.sciencegeek.net/APchemistry/organic/ochem.shtml">http://www.sciencegeek.net/APchemistry/organic/ochem.shtml</a>	IUPAC nomenclature website.  Notes.

	Isomerism: structural; geometrical; optical	tertiary) and phenols (iv) aldehydes and ketones (v) carboxylic acids, acyl chlorides and esters (vi) amines (primary only), amides, amino acids and nitriles		
		(b) interpret, and use the following terminology associated with organic reactions: (i) functional group (ii) homolytic and heterolytic fission (iii) free radical, initiation, propagation, termination (iv) nucleophile, electrophile (v) addition, substitution, elimination, hydrolysis (vi) oxidation and reduction [in equations for organic redox reactions, the symbols [O] and [H] are acceptable]	<a href="http://www.cem.msu.edu/~reusch/VirtualText/funcrx1.htm#halogen">http://www.cem.msu.edu/~reusch/VirtualText/funcrx1.htm#halogen</a> <a href="http://www.wbateman.demon.co.uk/asa2sums/sum5.3/freerad.htm">http://www.wbateman.demon.co.uk/asa2sums/sum5.3/freerad.htm</a>	Notes with animation.  Animation on free radical substitution.
		(c) describe $sp^3$ hybridisation, as	<a href="http://www.chemguide.co.uk/basicorg/bonding/methane.html">http://www.chemguide.co.uk/basicorg/bonding/methane.html</a>	Notes.

		in ethane molecule, $sp^2$ hybridisation, as in ethene and benzene molecules, and $sp$ hybridisation, as in ethyne molecule		
		(d) explain the shapes of, and bond angles in, the ethane, ethene, benzene, and ethyne molecules in relation to $\sigma$ and $\pi$ carbon-carbon bonds	<a href="http://www.chemguide.co.uk/basicorg/bonding/ethene.html">http://www.chemguide.co.uk/basicorg/bonding/ethene.html</a> <a href="http://www.chemguide.co.uk/basicorg/bonding/ethyne.html">http://www.chemguide.co.uk/basicorg/bonding/ethyne.html</a> <a href="http://www.bluffton.edu/~bergerd/Models/CS/structure.html">http://www.bluffton.edu/~bergerd/Models/CS/structure.html</a>	Notes.  Notes.  Notes with 3D models.
		(e) predict the shapes of, and bond angles in, molecules analogous to those specified in (d)		
		(f) describe structural isomerism		
		(g) describe geometrical isomerism in alkenes, and explain its origin in terms of restricted rotation due to the presence of $\pi$ bonds [use of E, Z nomenclature is <b>not</b> required]	<a href="http://www.creative-chemistry.org.uk/molecules/geometrical.htm">http://www.creative-chemistry.org.uk/molecules/geometrical.htm</a> <a href="http://www.bluffton.edu/~bergerd/Models/CS/truc6.html">http://www.bluffton.edu/~bergerd/Models/CS/truc6.html</a>	Notes with 3D models.  Notes with 3D models.

		(h) explain what is meant by a chiral centre	<a href="http://www.colby.edu/chemistry/OChem/DEMOS/Chirality.html">http://www.colby.edu/chemistry/OChem/DEMOS/Chirality.html</a>  <a href="http://www.bluffton.edu/~bergerd/Models/CS/chiral2.html">http://www.bluffton.edu/~bergerd/Models/CS/chiral2.html</a>  <a href="http://www.vuw.ac.nz/staff/paul_teesdale-spittle/organic/chiral_web/main.htm">http://www.vuw.ac.nz/staff/paul_teesdale-spittle/organic/chiral_web/main.htm</a>	<p>Animated tutorial.</p> <p>Notes with 3D models.</p> <p>Notes.</p>
		(i) deduce whether a given molecule is optically active based on the presence or absence of chiral centres and/or a plane of symmetry		
		(j) recognise that optical isomers have identical physical properties except in the direction in which they rotate plane-polarised light		
		(k) recognise that optical isomers have identical chemical properties except in their interactions with another chiral molecule		

		(l) recognise that different stereoisomers exhibit different biological properties, for example in drug action		
		(m) deduce the possible isomers for an organic molecule of known molecular formula		
		(n) identify chiral centres and/or geometrical isomerism in a molecule of given structural formula		
10.2 Hydrocarbons	<ul style="list-style-type: none"> <li>● Alkanes (exemplified by ethane)               <ul style="list-style-type: none"> <li>(i) Free-radical reactions</li> </ul> </li> <li>● Alkenes (exemplified by ethene)               <ul style="list-style-type: none"> <li>(i) Addition and oxidation reactions</li> </ul> </li> <li>● Arenes (exemplified by benzene and methylbenzene)</li> </ul>	(a) recognise the general unreactivity of alkanes, including towards polar reagents		

	<p>(i) Influence of delocalised <math>\pi</math> electrons on structure and properties</p> <p>(ii) Substitution reactions with electrophiles</p> <p>(iii) Oxidation of side-chain</p> <ul style="list-style-type: none"> <li>● Hydrocarbons as fuels</li> </ul>			
		<p>(b) describe the chemistry of alkanes as exemplified by the following reactions of ethane:</p> <p>(i) combustion</p> <p>(ii) substitution by chlorine and by bromine</p>		
		<p>(c) describe the mechanism of free-radical substitution at methyl groups with particular reference to the initiation, propagation and termination reactions</p>	<p><a href="http://www.chemhelper.com/frhalog.html">http://www.chemhelper.com/frhalog.html</a></p>	Notes.

		<p>(d) describe the chemistry of alkenes as exemplified, where relevant, by the following reactions of ethene:</p> <p>(i) addition of hydrogen, steam, hydrogen halides and halogens</p> <p>(ii) oxidation by cold, dilute manganate(VII) ions to form the diol</p> <p>(iii) oxidation by hot, concentrated manganate(VII) ions leading to the rupture of the carbon-to-carbon double bond in order to determine the position of alkene linkages in larger molecules</p>	<p><a href="http://chemistry.boisestate.edu/rbanks/organic/alkene.html">http://chemistry.boisestate.edu/rbanks/organic/alkene.html</a></p> <p><a href="http://www.ncl.ox.ac.uk/quicktime/hydrogenation.html">http://www.ncl.ox.ac.uk/quicktime/hydrogenation.html</a></p> <p><a href="http://www.jbpub.com/organic-online/movies/index.htm">http://www.jbpub.com/organic-online/movies/index.htm</a></p>	<p>Tutorials.</p> <p>Animation.</p> <p>Animations – addition of hydrogen, HX and Br<sub>2</sub> to alkene..</p>
		<p>(e) describe the mechanism of electrophilic addition in alkenes, using bromine/ethene as an example</p>		

		<p>(f) describe the chemistry of arenes as exemplified by the following reactions of benzene and methylbenzene:</p> <p>(i) substitution reactions with chlorine and with bromine</p> <p>(ii) nitration</p> <p>(iii) oxidation of the side-chain to give a carboxylic acid</p>	<p><a href="http://chemistry.boisestate.edu/rbanks/organic/aromatic.html">http://chemistry.boisestate.edu/rbanks/organic/aromatic.html</a></p> <p><a href="http://research.cm.utexas.edu/resources/ivers-on-movies/main.htm">http://research.cm.utexas.edu/resources/ivers-on-movies/main.htm</a></p> <p><a href="http://www.wbateman.demon.co.uk/asa2sums/sum5.3/electsub.htm">http://www.wbateman.demon.co.uk/asa2sums/sum5.3/electsub.htm</a></p>	<p>Tutorials.</p> <p>Notes and animation on nitration of benzene.</p> <p>Animation on nitration of benzene.</p>
		<p>(g) (i) describe the mechanism of electrophilic substitution in arenes, using the mono-nitration of benzene as an example</p> <p>(ii) describe the effect of the delocalisation of electrons in arenes in such reactions</p>	<p><a href="http://www.colby.edu/chemistry/OChem/DEMOS/EAS.html">http://www.colby.edu/chemistry/OChem/DEMOS/EAS.html</a></p> <p><a href="http://www.cem.msu.edu/~reusch/VirtualText/benzrx1.htm#benz1b">http://www.cem.msu.edu/~reusch/VirtualText/benzrx1.htm#benz1b</a></p>	<p>Animated slide show.</p> <p>Notes with animation.</p>
		<p>(h) predict whether halogenation will occur in the side-chain or aromatic nucleus in arenes depending on reaction conditions</p>		

		(i) apply the knowledge of positions of substitution in the electrophilic substitution reactions of mono-substituted arenes		
		(j) recognise the environmental consequences of carbon monoxide, oxides of nitrogen and unburnt hydrocarbons arising from the internal combustion engine and of their catalytic removal		
10.3 HALOGEN DERIVATIVE S	<ul style="list-style-type: none"> <li>Halogenoalkanes and halogenoarenes</li> <li>(i) Nucleophilic substitution</li> <li>(ii) Elimination</li> <li>Relative strength of the C-Hal bond</li> </ul>	<p>(a) recall the chemistry of halogenoalkanes as exemplified by</p> <p>(i) the following nucleophilic substitution reactions of bromoethane: hydrolysis; formation of nitriles; formation of primary amines by reaction with ammonia</p> <p>(ii) the elimination of hydrogen bromide from</p>	<p><a href="http://chemistry.boisestate.edu/rbanks/organic/halides.html">http://chemistry.boisestate.edu/rbanks/organic/halides.html</a></p> <p><a href="http://www.cem.msu.edu/~reusch/VirtualText/alhalrx2.htm#hal4">http://www.cem.msu.edu/~reusch/VirtualText/alhalrx2.htm#hal4</a></p>	<p>Notes.</p> <p>Notes with animation (require the <i>Chime</i> plugin).</p>

		2-bromopropane		
		(b) describe the mechanism of nucleophilic substitution in halogenoalkanes	<a href="http://www.colby.edu/chemistry/OChem/DEMOS/Substitution.html">http://www.colby.edu/chemistry/OChem/DEMOS/Substitution.html</a>  <a href="http://www.rod.beavon.clara.net/SN1.htm">http://www.rod.beavon.clara.net/SN1.htm</a>  <a href="http://www.rod.beavon.clara.net/SN2a.htm">http://www.rod.beavon.clara.net/SN2a.htm</a>	<p>Animated tutorial.</p> <p>Animation.</p> <p>Animation.</p>
		(c) interpret the different reactivities of halogenoalkanes and chlorobenzene with particular reference to hydrolysis and to the relative strengths of the C-Hal bonds		
		(d) explain the uses of fluoroalkanes and fluorohalogenoalkanes in terms of their relative chemical inertness		
		(e) recognise the concern about the effect of chlorofluoroalkanes (CFCs)	<a href="http://www.atmosphere.mpg.de/enid/1z2.html">http://www.atmosphere.mpg.de/enid/1z2.html</a>  <a href="http://www.nas.nasa.gov/About/Education/Oz">http://www.nas.nasa.gov/About/Education/Oz</a>	<p>Notes.</p> <p>Notes.</p>

		<p>on the ozone layer [the mechanistic details of how CFCs deplete the ozone layer are <b>not</b> required]</p>	<p><a href="#">one/</a></p>	
10.4 Hydroxy Compounds	<ul style="list-style-type: none"> <li>● Alcohols (exemplified by ethanol) <ul style="list-style-type: none"> <li>(i) Formation of halogenoalkanes</li> <li>(ii) Reaction with sodium; oxidation; dehydration</li> <li>(iii) The tri-iodomethane test</li> </ul> </li> <li>● Phenol <ul style="list-style-type: none"> <li>(i) Its acidity; reaction with sodium</li> <li>(ii) Nitration of, and bromination of, the aromatic ring</li> </ul> </li> </ul>	<p>(a) recall the chemistry of alcohols, exemplified by ethanol:</p> <ul style="list-style-type: none"> <li>(i) combustion</li> <li>(ii) substitution to give halogenoalkanes</li> <li>(iii) reaction with sodium</li> <li>(iv) oxidation to carbonyl compounds and carboxylic acids</li> <li>(v) dehydration to alkenes</li> </ul>	<p><a href="http://chemistry.boisestate.edu/rbanks/organic/EtOH+HBrTutorial2.htm">http://chemistry.boisestate.edu/rbanks/organic/EtOH+HBrTutorial2.htm</a></p> <p><a href="http://www.jbpub.com/organic-online/movies/index.htm">http://www.jbpub.com/organic-online/movies/index.htm</a></p>	<p>Notes.</p> <p>Animation – dehydration of alcohol.</p>
		<p>(b) classify hydroxy compounds into primary, secondary and tertiary alcohols</p>		

		(c) suggest characteristic distinguishing reactions, e.g. mild oxidation		
		(d) deduce the presence of a $\text{CH}_3\text{CH}(\text{OH})-$ group in an alcohol from its reaction with alkaline aqueous iodine to form tri-iodomethane		
		(e) recall the chemistry of phenol, as exemplified by the following reactions: (i) with bases (ii) with sodium (iii) nitration of, and bromination of, the aromatic ring		
		(f) explain the relative acidities of water, phenol and ethanol		Animation.
10.5 Carbonyl Compounds	<ul style="list-style-type: none"> <li>● Aldehydes (exemplified by ethanal)</li> <li>(i) Oxidation to carboxylic acid</li> </ul>	(a) describe the formation of aldehydes and ketones from, and their reduction to, primary and secondary alcohols respectively		

	<p>(ii) Reaction with hydrogen cyanide</p> <p>(iii) Characteristic tests for aldehydes</p> <ul style="list-style-type: none"> <li>● Ketones (exemplified by propanone and phenylethanone)</li> </ul> <p>(i) Reaction with hydrogen cyanide</p> <p>(ii) Characteristic tests for ketones</p>			
		(b) describe the mechanism of the nucleophilic addition reactions of hydrogen cyanide with aldehydes and ketones		
		(c) describe the use of 2,4-dinitrophenylhydrazine (2,4-DNPH) to detect the presence of carbonyl compounds	<a href="http://www.demochem.de/D-DNPH-e.htm">http://www.demochem.de/D-DNPH-e.htm</a>	Notes with video ( <a href="#">RealPlayer</a> needed).
		(d) deduce the nature (aldehyde		

		or ketone) of an unknown carbonyl compound from the results of simple tests (i.e. Fehling's and Tollens' reagents; ease of oxidation)		
		(e) describe the reaction of $\text{CH}_3\text{CO}-$ compounds with alkaline aqueous iodine to give tri-iodomethane	<a href="http://www.demochem.de/D-Jodof-e.htm">http://www.demochem.de/D-Jodof-e.htm</a>	Notes with video ( <a href="#">RealPlayer</a> needed).
10.6 Carboxylic Acids and Derivatives	<ul style="list-style-type: none"> <li>● Carboxylic acids (exemplified by ethanoic acid and benzoic acid) <ul style="list-style-type: none"> <li>(i) Formation from primary alcohols and nitriles</li> <li>(ii) Salt, ester and acyl chloride formation</li> </ul> </li> <li>● Acyl chlorides (exemplified by ethanoyl chloride) <ul style="list-style-type: none"> <li>(i) Ease of hydrolysis compared with</li> </ul> </li> </ul>	(a) describe the formation of carboxylic acids from alcohols, aldehydes and nitriles		

	<p>alkyl and aryl chlorides</p> <p>(ii) Reaction with alcohols, phenols and primary amines</p> <ul style="list-style-type: none"> <li>● Esters (exemplified by ethyl ethanoate and phenyl benzoate) <ul style="list-style-type: none"> <li>(i) Formation from carboxylic acids and from acyl chlorides</li> <li>(ii) Hydrolysis (under acidic and under basic conditions)</li> </ul> </li> </ul>			
		<p>(b) describe the reactions of carboxylic acids in the formation of</p> <ul style="list-style-type: none"> <li>(i) salts</li> <li>(ii) esters on reaction with alcohols, using ethyl ethanoate as an example</li> <li>(iii) acyl chlorides, using ethanoyl chloride as an example</li> </ul>		

		(c) explain the acidity of carboxylic acids and of chlorine-substituted ethanoic acids in terms of their structures		
		(d) describe the hydrolysis of acyl chlorides		
		(e) describe the reactions of acyl chlorides with alcohols, phenols and primary amines	<a href="http://chemistry.boisestate.edu/rbanks/organic/acidhalide.html">http://chemistry.boisestate.edu/rbanks/organic/acidhalide.html</a>	
		(f) explain the relative ease of hydrolysis of acyl chlorides, alkyl chlorides and aryl chlorides		
		(g) describe the formation of esters from acyl chlorides, using phenyl benzoate as an example		
		(h) describe the acid and base hydrolyses of esters	<a href="http://chemistry.boisestate.edu/rbanks/organic/ester+h.gif">http://chemistry.boisestate.edu/rbanks/organic/ester+h.gif</a>	Animations.

			<a href="http://chemistry.boisestate.edu/rbanks/organic/ester+oh.gif">http://chemistry.boisestate.edu/rbanks/organic/ester+oh.gif</a>	
10.7 Nitrogen Compounds	<ul style="list-style-type: none"> <li>● Primary amines (exemplified by ethylamine and phenylamine) <ul style="list-style-type: none"> <li>(i) Their formation</li> <li>(ii) Salt formation</li> <li>(iii) Other reactions of phenylamine</li> </ul> </li> <li>● Amides (exemplified by ethanamide) <ul style="list-style-type: none"> <li>(i) Their formation from acyl chlorides</li> <li>(ii) Their hydrolysis</li> </ul> </li> <li>● Amino acids (exemplified by aminoethanoic acid) <ul style="list-style-type: none"> <li>(i) Their acid and base properties</li> <li>(ii) Zwitterion formation</li> </ul> </li> <li>● Proteins <ul style="list-style-type: none"> <li>(i) Protein structure: primary;</li> </ul> </li> </ul>	(a) describe the formation of ethylamine (by nitrile reduction see also Section 10.3) and of phenylamine (by the reduction of nitrobenzene)		

	secondary; tertiary; quaternary structures (ii) The hydrolysis of proteins (iii) Denaturation of proteins			
		(b) explain the basicity of amines	<a href="http://www.colby.edu/chemistry/OChem/DEMOS/Amines.html">http://www.colby.edu/chemistry/OChem/DEMOS/Amines.html</a>	Animated tutorial.
		(c) explain the relative basicities of ammonia, ethylamine and phenylamine in terms of their structures		
		(d) describe the reaction of phenylamine with aqueous bromine		
		(e) describe the formation of amides from the reaction between $\text{RNH}_2$ and $\text{R}'\text{COC}/$		
		(f) describe amide hydrolysis on treatment with aqueous alkali	<a href="http://chemistry.boisestate.edu/rbanks/organic/amide.html">http://chemistry.boisestate.edu/rbanks/organic/amide.html</a>	Animations.

		or acid		
		(g) describe the acid/base properties of amino acids and the formation of zwitterions		
		(h) describe the formation of peptide (amide) bonds between amino acids and, hence, explain protein formation	<a href="http://michele.usc.edu/java/pept.html">http://michele.usc.edu/java/pept.html</a>	Animation on peptide formation.
		(i) list the major functions of proteins in the body		
		(j) describe the hydrolysis of proteins		
		(k) explain the term primary structure of proteins		
		(l) recognise that the twenty amino acids that make up all the proteins in the body are $\alpha$ -amino acids with the general formula $RCH(NH_2)CO_2H$ , and be able	<a href="http://chemmac1.usc.edu/a-acids/Aminoacids.htm">http://chemmac1.usc.edu/a-acids/Aminoacids.htm</a>	Notes with 3D models (require the <i>Chime</i> plugin) of amino acids.

		to interpret the properties of $\alpha$ -amino acids in terms of the nature of the R group		
		(m) describe the secondary structure of proteins: $\alpha$ -helix and $\beta$ -pleated sheet and the stabilisation of these structures by hydrogen bonding	<a href="http://www.med.unibs.it/~marchesi/proteins.html#secondary">http://www.med.unibs.it/~marchesi/proteins.html#secondary</a> <a href="http://webhost.bridgew.edu/fgorga/proteins/default.htm">http://webhost.bridgew.edu/fgorga/proteins/default.htm</a> <a href="http://www.moleculesinmotion.com/SecStrLA/menu.html">http://www.moleculesinmotion.com/SecStrLA/menu.html</a>	Notes with 3D-models (require the <i>Chime</i> plugin)
		(n) state the importance of the tertiary protein structure and explain the stabilisation of the tertiary structure with regard to the R groups in the amino acid residues (ionic linkages, disulphide bridges, hydrogen bonds and van der Waals' forces)		
		(o) describe (i) the quaternary structure of proteins (ii) the protein components	<a href="http://www.med.unibs.it/~marchesi/hemoglob.html">http://www.med.unibs.it/~marchesi/hemoglob.html</a> <a href="http://www.med.unibs.it/~marchesi/haemogl2">http://www.med.unibs.it/~marchesi/haemogl2</a>	Notes with 3D-model (requires the <i>Chime</i> plugin)

		of haemoglobin	<a href="#">html</a> <a href="http://webhost.bridgew.edu/fgorga/proteins/default.htm">http://webhost.bridgew.edu/fgorga/proteins/default.htm</a>	
		(p) explain denaturation of proteins by heavy metal ions, extremes of temperature and pH changes	<a href="http://www.lewport.wnyric.org/jwanamaker/animations/Enzyme%20activity.html">http://www.lewport.wnyric.org/jwanamaker/animations/Enzyme%20activity.html</a>	Animated tutorial – denaturation of enzyme.
		(q) apply the knowledge of the loss and formation of secondary and tertiary structures to interpret common everyday phenomena		