Review of A-level Chemistry Content

David Read & Charles Harrison **August 2010**

School of Chemistry

University of Southampton

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Includes: AQA, Edexcel, OCR A and OCR B (Salters), WJEC and CCEA

2008- specifications

Includes a summary of discussions about the prospects for the 2010 intake which took place between academics & teachers at our Post-16 teachers' day on 10/06/10

This edition was created on 27/08/10

Check if this is the latest edition at: ***http://www.edshare.soton.ac.uk/5853/***

Introduction

This review is a follow up to the document produced in June 2007. Since September 2008, A-level chemistry students in England and Wales have been following new specifications which are different to those studied previously. This review is based around the new A-levels and is intended to give university staff a clear indication of what is covered at A-level. In order to keep the document as simple as possible (and simpler than the old one!), we have focussed on detailing mainly those topics which are dealt with by all or most of the specifications. Remarks on less common topics are added in notes rather than being detailed in the tables. To find out more about the precise detail of what is covered, the specifications can easily be found online (see links at the end of this document).

One feature of these modular A-levels is the fact that different topics are taught in slightly different orders in different specifications, and there is no categorisation under 'Inorganic', 'Organic' and 'Physical'. To make the document easier to follow, we have tried to group topics together under these headings, while including topics like atomic structure, types of bonding and spectroscopy under 'General chemistry'. The contents page should allow for relatively easy navigation.
The tables should be easy to follow, with '**AS**' and '**A2**' indicating which part of the course the topic is found in, and '**X**' indicating that the topic is not explicitly covered in that particular specification. Note that this doesn't necessarily mean that students studying that specification haven't been exposed to that topic, but it is probably a safe bet to assume this. Many teachers report difficulties in getting through all of the content at AS level, so it is unlikely that they will spend time teaching topics which are not on their specification.

The key change which is **not** reflected in this report is the nature of practical assessment in the new specifications. Any sort of coursework/extended practical is now absent from all specifications apart from **OCR Salters**. As a consequence, a significant proportion of chemistry students will arrive at university having never had to go through the process of planning an investigation, before analysing and evaluating their results/outcomes. Of course, many teachers will still ensure that their students develop these skills in their practical work, but we have spoken to many students who are doing nothing more than the bare minimum of practical work in their lessons, and such individuals will need more support in making the transition to the university laboratory. For the 2010 cohort and beyond, we need to be prepared for a broad spectrum of practical abilities, with a longer tail of 'weak' students that we're used to. Particular deficiencies may be found in some students abilities to write reports, and plan practical work effectively.

Remember that bright students today have the same potential as bright students in previous years. If they want to do chemistry and are motivated, they have to potential to succeed at university as long as we are mindful of the fact that they have by-and-large had a different experience at A-level to that of their predecessors.

Please report any errors/omissions to me at: d.read@soton.ac.uk **David Read Aug 2010**

Contents

General chemistry: atomic structure

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Atoms (+ ions and isotopes) are made from protons, neutrons and electrons. Atomic symbols in the periodic table can be used to work out how many of each particle is present. **Students should be able to draw representations of atoms, define ions isotopes etc**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Electron shells are made up of sub-shells and orbitals. **Students should be able to work out electron configurations.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Atomic orbitals have different shapes. **Students should be able to describe the shapes of s and p orbitals (& d orbitals for WJEC)**	**X**	**AS**	**AS**	**X**	**AS**	**AS**
Electronic structure influences the chemical properties of an element (ion formation to get noble gas configuration). **O: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$ (or [Ne] $3s^2\ 3p^4$). They can also draw 'electrons (arrows) in boxes'**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Ionisation is the removal of one or more electrons, and ionisation energy is affected by atomic radius, nuclear charge and electron shielding. **Students should be able to explain the role of atomic radius, nuclear charge and electron shielding in magnitudes of IE values, & describe evidence for the existence of sub-shells.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Ionisation energies decrease down a group (e.g. group 2). **Students should be able to use similar arguments to those above to explain this.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Successive ionisation energies of elements provide evidence for the existence of sub-shells. **Students should be able to explain the trend in successive ionisation energies for an element (e.g. Na) using ideas about the charge on the ion and sub-shells.**	**X**	**AS**	**AS**	**AS**	**AS**	**AS**

OCR Salters requires knowledge of ideas about nuclear fusion forming elements in stars, and also covers nuclear fission. Radioactive decay and nuclear equations are also covered by **Salters** and by **WJEC**. Atomic spectra are covered in some detail by **Salters, WJEC** and **CCEA**, incorporating absorption/emission of quantised energy, with the precise wavelengths being characteristic of the element. Lyman, Balmer and Paschen series are covered.

General chemistry: moles and equations cont.

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Definitions of Relative atomic, isotopic and molecular mass on C-12 scale. **Students should be able to deduce relative atomic mass from % abundances/masses.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Relative masses can be measured using a mass spectrometer – details limited to vaporisation, ionisation, acceleration, deflection, detection. OCR A and CCEA do not require detailed knowledge of how a mass spectrometer works ***Expanded on at A2 level.*** **Students can derive R.A.M. (or R.F.M.) and % isotopic abundance from spectra. Note that Salters teaches the concept of TOF MS rather than the traditional sector method.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Fragmentation occurs in mass spectrometry leading to peaks in the spectrum at lower m/z values. **Students should recognise that fragmentation patterns give information regarding structure (e.g. loss of CH_3, C_2H_5 etc).**	**A2**	**AS**	**AS**	**AS**	**X**	**AS**
The mole is a measure of the amount of a substance, **Students should be able to calculate no. of moles, no. of particles, concentration of solutions, moles from gas volumes (at RTP), rearranging equations where appropriate.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Empirical formulae can be calculated from information regarding masses of elements in compounds, experimental results (e.g. from combustion analysis) or % compositions. **Students should be able to carry out the appropriate calculations.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Molecular formulae can be calculated using the empirical formula/R.F.M. **Students should be able to carry out the appropriate calculations.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Chemical equations can be used to show what happens in a reaction. **Students should be able to balance equations (inc. state symbols), and use balanced equations to work out reacting masses/gas volumes.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**

General chemistry: moles and equations cont.

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Acid base titrations are used in quantitative analysis (Note that CCEA specifies a requirement for knowledge of back titrations) **Students should be able to perform appropriate calculations.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
The theoretical yield of a reaction is the maximum amount that could be obtained in a reaction, while the % yield is the actual amount obtained. **Students should be able to calculate theoretical and percentage yields.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Students should be able to explain what is meant by the term atom economy and carry out associated calculations.	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Ionic equations only show the reacting particles, and the charges on both sides must balance. **Students should be able to write ionic equations for relevant reactions (although they often find it very difficult).**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**

AQA is the only board which covers the ideal gas equation (although it crops up in A-level physics).

General chemistry: covalent bonding and shapes of molecules

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Molecules are groups of atoms held together by covalent bonds (shared pairs of electrons). **Students should be able to represent molecules using dot+cross diagrams (Lewis structures normally not taught).**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
π bonds are formed by overlap of two p orbital *(see also p.20 and p.21)*. **Students should be able to describe the bonding in ethene and represent that molecule using a dot-and-cross diagram or rough sketches of the molecular orbitals. Note that knowledge of σ and π bonding may be patchy across the cohort. AQA and Salters don't cover the shape of p-orbitals, so understanding of π bonding may be very limited.**	**(AS)**	**AS**	**(AS)**	**AS**	**AS**	**AS**

General chemistry: covalent bonding and shapes of molecules cont.

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Dative (coordinate) covalent bonding is where both electrons come from one atom. (e.g. NH_4^+)	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
The shape of a molecule is determined by the no. of e^- pairs around the central atom. **Students should be able to explain that lone pairs repel more than bonding pairs.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
VSEPR theory can be used to work out the shapes of molecules and ions. **Students should be able to derive the shapes of species up to 6 coordinate species**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**

General chemistry – intermolecular forces

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
The ability of an atom of an element to attract bonding electrons in a covalent bond is its electronegativity, measured on the Pauling scale.	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Polar covalent bonds arise when the two atoms involved have differing electronegativities.	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Polar bonds may lead to a polar molecule, except in cases where the polar bonds point in opposite directions, so the dipoles cancel each other out. **Students may or may not have been taught this with reference to symmetry.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Intermolecular forces are much weaker than bonds between atoms.	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**

Note that **Salters** uses'Intermolecular bond' rather than 'force', to the chagrin of many teachers. Teachers have had to work hard to convince GCSE students that they should talk about 'forces between molecules' rather than 'bonds'! This development muddies the waters somewhat.

Temporary dipole-induced dipole (Van der Waal) forces are the weakest forces. **Students should be able to explain the effect of the size and shape of a molecule on the strength of intermolecular forces, and the consequent effect on boiling & melting points.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Polar molecules experience attractive permanent dipole-permanent dipole forces, which are weak (but stronger than VdW forces).	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**

General chemistry – intermolecular forces cont.

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Hydrogen-bonding arises when H is bonded to highly electronegative atoms. **Students can show H-bonding in water/ammonia by drawing diagrams showing lone pairs, dipoles and dashed lines representing H-bonds.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Hydrogen bonding leads to higher m.pts and b.pts, and makes compounds soluble in water. **Students should be able to explain why ice floats on water using ideas about H-bonds.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**

General chemistry – ionic, metallic and giant covalent substances

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Ionic bonding arises from the strong electrostatic attraction between ions of opposite charge.	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Ions are formed when atoms gain/lose electrons to obtain a noble gas configuration. **Students should be able to represent ions using dot-and-cross diagrams, and derive the formula of an ionic compound using information about ionic charges.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Sodium chloride has a giant ionic lattice structure (cube shaped) with many strong ionic bonds. **Students should be able to describe/explain properties of ionic cpds (high m.pt/b.pt, conductivity) in terms of energy required to break bonds/ion mobility in different states.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Metals have giant structures with positive ions in a lattice surrounded by a sea of delocalised e^-. **Students should be able to describe and explain the properties (m.pt, b.pt, conductivity, ductility/malleability) with reference to structure.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Diamond, graphite (allotropes of C) and SiO_2 have giant covalent structures. **Students should be able to describe/explain properties of substances (type of bonding).**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**

WJEC and **Edexcel** also require knowledge of carbon nanotubes, with Edexcel also discussing applications of such materials e.g. in drug delivery. **Salters** requires a discussion of the differences between the structures of CO_2 and SiO_2. **Edexcel** is the only specification to go into any detail on polarisation/polarisability, but teaching of the topic is required for **AQA** to explain the covalent character of ionic compounds (p.26).

General chemistry – spectroscopy and chromatography

Note that coverage of mass spectrometry was discussed on p.5.

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
IR radiation causes bonds in molecules to vibrate, and this is the basis for IR spectroscopy. **Students should be able to interpret spectra of compounds such as alcohols and carbonyl compounds. Edexcel is more detailed than the others.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Students should be able to relate global warming to the absorption of IR radiation by greenhouse gases in the atmosphere.	**AS**	**AS**	**AS**	**AS**	**X**	**AS**
N.M.R. spectroscopy can be used to gain information about the structure of organic molecules. **Students should be able to interpret simple spectra to identify the no.s of protons in different environments with reference to given data on chemical shift values.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Peaks in N.M.R. spectra can be split by spin-spin coupling. **Students should be able to use the n+1 rule to deduce the no. of protons on an adjacent carbon atom from the splitting pattern in an N.M.R. spectrum. OCR requires explanation of the identification of labile protons using D_2O.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Carbon-13 NMR spectroscopy can provide further information regarding structure	**A2**	**X**	**A2**	**X**	**X**	**X**
Chromatography can be used to separate mixtures (details below).	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
TLC and paper chromatography (CCEA discusses 2 way chromatography)	**X**	**A2**	**A2**	**A2**	**A2**	**A2**
Gas (or gas-liquid) chromatography	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Chromatography combined with MS (e.g. GC-MS)	**X**	**X**	**A2**	**A2**	**X**	**A2**

The level of N.M.R. theory taught will vary. Exam boards do not examine theory, so some teachers will have kept it simple.

Green chemistry is a feature of some of the new specifications, with **OCR** and **Edexcel** being particularly detailed. Topics that students may have covered include biofuels and other alternatives, the importance of catalysts, waste reduction and use of renewable materials/energy sources. See the specifications for details.

Inorganic chemistry: the periodic table and ionisation energies

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Atomic radii, ionic radii, electronegativity, and thermal/electrical conductivity change as you go across a period. The topic is only mentioned vaguely in Salters, WJEC and Edexcel. **Students should be able to describe & explain trends in these properties across a period.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Melting and boiling points across a period depend on the type of bonding/structure present. **Students should be able to explain the trends in melting points of the elements across a period using ideas from the previous sections (Bonding and Structure).**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Ionisation energy generally increases across a period. **Students can explain the trend in IE across period 3 using ideas about nuclear charge, s/p subshells, spin pairing and electron repulsion (see also below).**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
There is a drop in ionisation energy from group 2 to group 3. **Students should be able to explain this in terms of the orbitals the electrons are found in and the shielding by other electrons. Note that precise coverage is unclear in the specifications e.g. OCR A explicitly states that knowledge of these anomalies 'will not be tested'. However evidence from our discussions with current A-level students shows that they are generally still aware of the pattern described here, and the drop from group 5 to 6 may also have been discussed.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**

Inorganic chemistry – redox processes

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Reduction and oxidation occur simultaneously in redox reactions. Oxidising agents accept electrons, reducing agents donate electrons. **Students should be able to write half-equations to show redox reactions.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Oxidation no.s or oxidation states (note that the two terms are often used used interchangeably) can be assigned using a set of simple rules. **Students should be able to work out the oxidation state of an element in a compound/ion.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Oxidation state goes up when electrons are lost (oxidation) and oxidation state goes down when electrons are gained (reduction). **Students should recognise that disproportionation can occur e.g. $Cl_2 + H_2O \rightarrow HOCl + HCl$**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**

AQA specifies knowledge of extraction of metals such as iron, steel and aluminium. **Salters** also teaches about the recycling of metals.

Inorganic chemistry – s-block elements

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Key trends of s-block elements: **Students should be able to describe and explain the trends of the following properties down groups 1 and 2: atomic and ionic radii, reactivity, electronegativity, m. pt/b. pt**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Ions of s-block metals have distinctive flame colours (due to electronic transitions etc). **Students should recall that using a spectroscope gives a line emission spectrum.**	**X**	**AS**	**X**	**X**	**AS**	**AS**
Group I metals are the most reactive metals, which are easily oxidised to M^+ ions. **Students should be able to explain the trend in reactivity down the group.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Group 2 metals react with water to produce hydroxides $M(OH)_2$, oxygen to produce oxides MO and chlorine to produce chlorides MCl_2. **Students can write balanced symbol equations to show these reactions.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**

Inorganic chemistry – s-block elements cont.

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
s-block metal oxides and hydroxides are bases, forming alkaline solutions. **Students should be able to recall approximate pH values of these solutions.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Group 2 metal carbonates decompose forming the oxide and carbon dioxide.	**X**	**AS**	**AS**	**AS**	**X**	**AS**
Students should be able to describe and explain the trend in the stabilities of the group 1 carbonates & nitrates as well as the group 2 nitrates.	**X**	**AS**	**X**	**X**	**X**	**X**
Students should be able to describe and explain the trend in the stabilities of the group 2 carbonates	**X**	**AS**	**AS**	**AS**	**X**	**AS**

Inorganic chemistry – halogens and halides

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
The halogens are reactive non-metals in group 7: **Students should be able to describe trends in b.pt and explain the reactivities in displacement reactions in terms of oxidising power. They can link this to size & attraction of electrons. Appearance in aqueous and organic solutions is also discussed.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
The electronegativity of the halogens decreases down the group	**AS**	**X**	**AS**	**X**	**X**	**AS**
The reducing power of halide ions increases down the group. **Students should be able to describe this trend using converse arguments to those used above.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Chlorine reacts with water and alkalis in disproportionation reactions to give useful products. **Students should be able to explain why these reactions are useful, write balanced equations and assign oxidation states appropriately.**	**AS**	**AS**	**AS**	**AS**	**X**	**AS**

Inorganic chemistry – halogens and halides cont.

Salts of different halides react differently with sulphuric acid. **Students should be able to write equations for these reactions and assign oxidation states to identify oxidation and reduction.**	**AS**	**AS**	**X**	**X**	**X**	**AS**
Silver nitrate and ammonia can be used to identify halide ions present in salts. **Students should be able to describe the appearance of precipitates and the effect of adding dil/conc ammonia solution and write ionic and full equations can be written.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Hydrogen halides are colourless, acidic gases. **Students should know the trends in thermal stability of hydrogen halides.**	**X**	**AS**	**X**	**X**	**X**	**AS**

Salters require a description of the extraction of chlorine by electrolysis of brine and also requires knowledge of the risks of storage and transport and the recall of uses. **CCEA** includes reactivity towards hydrogen, phosphorous and sodium as well as NaOH and Fe^{II} and Fe^{III} **OCR** includes reactivity towards NaOH, and **Edexcel** includes reactivity towards Fe^{II} and Fe^{III}

Inorganic chemistry – transition metals, complex ions and metal-aqua ions

WJEC is unique in its extensive coverage of p-block elements including: inert pair effect, expansion of the octet rule, general properties of p block chlorides and general trends down each group. See the specification for details.

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Transition metals are found in the d-block and can form one or more stable ions with a partially filled d-subshell. **Students should be able to deduce electron configurations on atoms and ions and show them using standard notation and electrons (arrows) in boxes.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Transition metals have similar chemical properties, and a range of special chemical properties (complex ion formation, coloured ions, catalysis, and variable [O] state).	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**

Inorganic chemistry – transition metals, complex ions and metal-aqua ions cont.

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Transition metals and their compounds make good catalysts because they can change oxidation states by gaining and/or losing electrons.	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Complex ions are metal ions surrounded by ligands. **Students should be able to use the term coordination number in relation to octahedral, tetrahedral and linear complexes. They should also be able to draw complexes showing coordinate bonds with wedges/dashes. They should also be able to work out the charge on the complex from the [O] state of the metal and the charge(s) on the ligand(s).**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Ligands donate one or more lone pairs to form coordinate bonds.	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Complexes of transition metals sometimes exhibit stereoisomerism	**A2**	**A2**	**A2**	**X**	**X**	**A2**
Transition metal complexes are typically coloured	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Students should be able to explain why transition metal complexes have colour including knowledge of partially filled d orbitals	**A2**	**A2**	**X**	**A2**	**A2**	**X**
Colorimetry is a technique that can be used in experiments where measurements involving coloured solutions are required.	**A2**	**X**	**X**	**A2**	**X**	**A2**
Ligand substitution reactions can occur. **Students should be able to write equations for a range of ligand exchange reactions, noting colour changes, coordination no./shape changes and instances of partial exchange.**	**A2**	**A2**	**A2**	**A2**	**X**	**A2**
Complex ions can have different stabilities. **Students should be able to explain/predict the stability of complex ions in terms of the entropy changes which would occur during ligand exchange reactions.**	**A2**	**X**	**A2**	**X**	**X**	**A2**
K_{stab} is the equilibrium constant for the formation of a complex ion.	**X**	**X**	**A2**	**X**	**X**	**X**
Haemoglobin is a complex of iron with the multidentate ligand haem. Ligand substitution reactions are important in the transportation of oxygen.	**A2**	**X**	**A2**	**X**	**X**	**A2**

Inorganic chemistry – transition metals, complex ions and metal-aqua ions cont.

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
EDTA is a commonly used hexadentate ligand.	**A2**	**A2**	**X**	**A2**	**X**	**A2**
Metal aqua ions are formed by the co-ordination of water molecules to transition metals.. **Students should be able to represent aqua ions e.g. $[Fe(H_2O)_6]^{2+}$ using 3D diagrams.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Metal-aqua ions react with hydroxide to form uncharged metal hydroxides which are coloured solids and precipitate out of solution. **Students should be able to describe observations and write balanced equations to explain the outcome of these reactions.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
(with reference to previous entry) Addition of ammonia in small quantities and in excess can lead to further reactions. **Students should be able to describe observations and write balanced equations to explain the outcome of these reactions.**	**A2**	**A2**	**X**	**A2**	**X**	**X**
Redox titrations can be performed using oxidants (MnO_4^-, $Cr_2O_7^{2-}$). **Students should be able to perform redox titrations and associated calculations.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Students should have an awareness of the ability of transition metals to undergo redox reactions	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Students should be able to perform Iodine- thiosulphate titrations and appropriate calculations	**X**	**A2**	**A2**	**X**	**A2**	**A2**
Transition metal ions undergo characteristic reactions with aqueous hydroxide	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Students should be able to rationalise precipitation reactions as acid-base equilibria	**A2**	**A2**	**X**	**X**	**X**	**A2**

Note that the old specifications contained more detail on the examples that students were required to know about. Coverage is patchier and diverse in the new specs, so we haven't included a full breakdown. Details can be found in the specs. Students will have studied examples of transition metals and their chemistry, but which ones will depend on the specification and the teacher.

Inorganic chemistry – the elements of period 3

Note that the study of periodicity has been greatly cut down compared with the pre-2008 A-levels.

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
The elements of period 3 react with oxygen to form oxides. **Students should be able to recall the formulae and describe trends in oxidation state, bonding and structure of the period 3 oxides.**	**A2**	**X**	**X**	**X**	**X**	**A2**
The properties of period 3 oxides are related to their bonding and structure. **Students should be able to describe trends in melting point and acidity/alkalinity of the oxides in solution explaining these trends using ideas about bonding and structure.**	**A2**	**X**	**X**	**X**	**X**	**A2**
The elements of period 3 react with chlorine to form chlorides. **Students should be able to relate properties to trends in bonding/structure.**	**X**	**X**	**X**	**X**	**X**	**A2**

Organic chemistry – reactions covered throughout A-level

Reaction	AQA	Ed	OCR A	Salters	WJEC	CCEA
Acyl chlorides:						
+ water → acid	A2*	A2	**X**	**X**	A2	A2
+ alcohols → esters	A2*	A2	**X**	**X**	A2	A2
+ conc. ammonia → amides	A2*	A2	**X**	A2	A2	A2
+ amines → amides	A2*	A2	**X**	**X**	A2	A2
Addition polymerisation	AS	AS	AS	AS	AS	AS
Alcohols:						
+ [O] → aldehydes/carboxylic acids	AS	AS	AS	AS	AS	AS
+ HCl → chloroalkane	**X**	**X**	**X**	AS	A2	AS
+ PCl_5 → chloroalkane	**X**	AS	**X**	**X**	**X**	AS
dehydration → alkenes	AS	**X**	AS	AS	**X**	AS
+ carboxylic acids – esters	A2	A2	AS	A2	A2	AS
+ sodium → sodium ethoxide	**X**	AS	**X**	**X**	**X**	AS
Amide hydrolysis	A2[1]	**X**	A2[1]	A2	A2	**X**
Amine formation:						
alkyl halide + ethanolic ammonia	A2	AS	A2	AS	A2	A2
reduction of aromatic nitro compounds	A2	A2	A2	**X**	**X**	A2
reduction of nitrile	A2	**X**	**X**	**X**	A2	A2
Amines:						
+ acid → salt	A2	A2	A2	A2	A2	A2
+ acyl chloride → amide	A2	A2	**X**	A2	A2	A2
+ alkylhalide → secondary amine	A2	A2	**X**	**X**	A2	A2
+ P_2O_5 → nitrile	**X**	**X**	**X**	**X**	**X**	A2
Azo dye formation	**X**	A2	A2	A2	A2	A2
Carbonyl compounds (aldehydes + ketones):						
formation from alcohols	AS	AS	AS	A2	A2	A2
oxidation of aldehydes to carboxylic acids	AS	AS	AS	A2	A2	A2
+ HCN → cyanohydrin	A2*	A2	**X**	A2*	A2*	A2*
+ hydride → alcohol	A2*	A2	A2*	**X**	A2	A2
+ 2,4-DNP	**X**	A2	A2	**X**	A2	A2
Carboxylic acids						
+ alkalis/carbonates	A2	A2	A2	A2	A2	A2
+ metals	**X**	**X**	A2	**X**	**X**	**X**
+ alcohols → esters	A2	A2	A2	A2	A2	A2
+ $LiAlH_4$ → alcohol	**X**	A2	**X**	**X**	A2	A2
+ PCl_5 → acyl chloride	**X**	A2	**X**	**X**	A2	A2
Carboxylic acid (aromatic) formation by [O] of methyl side chains with Mn (VII)/H^+	**X**	**X**	**X**	**X**	A2	**X**
Combustion of alkanes	AS	AS*	AS	AS	AS	AS

[1] In the context of hydrolysis of proteins and polyamides

Reaction	AQA	Ed	OCR A	Salters	WJEC	CCEA
Condensation polymerisation	A2	A2	A2	A2	AS	AS
Cracking/reforming	AS	**X**	AS	AS	AS	AS
Electrophilic addition reactions of alkenes:						
+ bromine	AS*	AS*	AS*	AS*	AS*	AS
+ hydrogen bromide	AS*	AS*	AS*	AS*	AS*	AS*
+ hydrogen (Ni or Pt cat)	**X**	AS	AS	AS	AS	A2
+ water (H_2SO_4 or H_3PO_4)	AS*	**X**	AS	AS	AS	AS
+ permanganate → diols	**X**	AS	**X**	**X**	**X**	**X**
Electrophilic substitution of aromatics:						
halogenation	**X**	A2*	A2*	A2*	A2*	A2*
nitration	A2*	A2*	A2*	A2	A2*	A2*
sulfonation	**X**	A2	**X**	A2	**X**	**X**
Friedel-Crafts alkylation	**X**	A2*	**X**	A2	A2	**X**
Friedel-Crafts acylation	A2*	A2*	**X**	A2	**X**	**X**
Elimination	AS*[2]	AS	AS	AS	AS	AS
Ester formation – **also see alcohols/acids**	A2	A2	A2	A2	A2	A2
Ester hydrolysis	A2	A2	A2	A2	**X**	A2
Fermentation	AS	**X**	AS	**X**	**X**	AS
Halogenoalkanes:						
+ H_2O/OH^- → alcohol	AS*	AS*	AS*	AS*	AS*	AS*
+ ethanolic OH^- → alkene	AS*	AS	AS	AS	AS	AS
+ ethanolic ammonia → amine	AS	AS	A2	AS	A2	**X**
+ amines → secondary amines	A2*	**X**	**X**	**X**	A2	AS
+ CN^-	**X**	**X**	**X**	**X**	A2	A2
Halogenation of alkanes	AS*	AS*	AS*	AS*	AS*	AS*
Hydrogenation of benzene	**X**	A2	**X**	**X**	**X**	**X**
Nucleophilic addition **(see carbonyl cpds)**						
+ HCN → cyanohydrin	A2*	A2*	**X**	A2	A2*	A2*
+ hydride → alcohol	A2*	A2	A2*	**X**	**X**	A2
Nucleophilic substitution	AS*	AS*	AS*	AS*	AS	AS
Ozone depletion	AS	AS*	~	AS	**X**	**X**
Phenols:						
+ alkalis (not carbonates)	**X**	**X**	A2	A2	A2	**X**
test with iron (III) chloride	**X**	**X**	**X**	A2	A2	**X**
+ acyl chlorides → esters	**X**	**X**	**X**	A2	A2	**X**
+ bromine → 2,4,6-tribromophenol	**X**	A2	A2	**X**	A2	**X**
+ nitric acid → 2,4,6-trinitrophenol	**X**	A2	**X**	**X**	**X**	**X**
Transesterification	A2	A2	**X**	**X**	**X**	**X**

Note: '*' indicates that the specification requires knowledge of the mechanism for that reaction. As is mentioned elsewhere in this review, Edexcel and CCEA are the only specs to require S_N1 & S_N2. The generic 'nucleophilic substitution' reaction they all learn about is actually the S_N2 mechanism, although few of them will use the term.

[2] The mechanism for base catalysed elimination is needed, but not for acid catalysed elimination.

Organic chemistry – functional groups and nomenclature

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Students should be able to recognise and demonstrate the ability to name compounds in the following homologous series: alkanes, branched alkanes, cycloalkanes, halogenoalkanes, alkenes, alcohols, carboxylic acids, esters	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Students should be able to recognise and demonstrate the ability to name compounds in the following homologous series: aldehydes and ketones	**AS**	**AS**	**AS**	**AS**	**A2**	**AS**
Students should have knowledge of tests for aldehydes and ketones	**A2**	**A2**	**A2**	**X**	**A2**	**A2**
Students should be able to describe a test for a methyl carbonyl group	**X**	**A2**	**X**	**X**	**A2**	**X**
Students should be aware of the structure and properties of fats and oils (CCEA requires knowledge of their iodine value)	**A2**	**A2**	**A2**	**A2**	**X**	**A2**
Students should be aware of the positive and negative implications for Biodiesel use	**A2**	**A2**	**A2**	**X**	**X**	**X**
Students should be able to recognise and demonstrate the ability to name compounds in the following homologous series: acyl chlorides	**A2**	**A2**	**X**	**A2**	**A2**	**A2**
Students should be able to recognise and demonstrate the ability to name compounds in the following homologous series: acid anhydrides	**A2**	**X**	**A2**	**X**	**A2**	**X**

Individual specifications can be referred to for further clarification on the requirements for recognising/naming homologous series. Generally, molecules with more than 6 C atoms will not be tested. The naming of ethers is not specified however may still be taught. Students will have varying levels of confidence with nomenclature with many being unfamiliar with non IUPAC names such as acetone or acetic acid.

Note that we have expanded on the details regarding some of the homologous series on pages 21-24.

Organic Chemistry – isomerism

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Representing organic compounds: **Students should be able to represent organic compounds using the following:** **Molecular formulae, structural formulae, displayed formulae and skeletal formulae (they should also be able to use general formulae and empirical formulae).** **AQA** and **CCEA** do not specify skeletal formulae, however many teachers will still teach them. Some students will be able to draw different representations without understanding what is meant by terms such as 'displayed formula'.	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Structural isomers have the same molecular formula, but their atoms are arranged in a different way (to include chain isomers e.g. butane vs methyl propane and positional isomers e.g. propan-1-ol vs propan-2-ol). **Students should be able to recognise, name and predict the existence of isomers within the homologous series encountered at this level.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Geometric isomers are found in alkenes which have two different groups attached to each carbon of the C=C *(see also p.6 and p.21)*. ***E/Z* nomenclature is taught in favour of traditional cis/trans, although they may still be taught in parallel. Students may find the distinction confusing.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Optical isomers are mirror images of each other. **Students should be able to describe the optical activity of enantiomers.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Most optical isomers are produced as racemic mixtures in the lab. **Students should be able to identify chiral centres in molecules. Note that Edexcel, WJEC and CCEA cover this in great detail**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Optical isomers can rotate plane polarised light (although not when in a racemic mixture)	**A2**	**A2**	**X**	**X**	**A2**	**A2**

Organic chemistry – hydrocarbons

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Alkanes are saturated hydrocarbons which are useful as fuels. **Students should be able to write a balanced symbol equation to represent combustion.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Alkenes are unsaturated hydrocarbons which exhibit geometric isomerism due to restricted rotation around the C=C bond *(see also p.6 and p.20)*. **Students should be able to explain restricted rotation in terms of the formation of a π-bond when the two p-orbital overlap. Students should also recognise that the reactivity of alkenes is due to the double bond being an a region of high e- density (Salters students may have limited understanding for the reasons discussed previously).**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Crude oil can be separated into fractions containing hydrocarbons of different chain lengths by using fractional distillation.	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Students should be able to explain varying boiling points of alkanes (branched and straight chain) in terms of VdW forces and packing. **(Although AQA doesn't specify this, VdW forces are covered elsewhere in the spec, so students should reasonably be expected to make the link)**	**X**	**AS**	**AS**	**AS**	**AS**	**AS**
Branched-chain alkanes and cycloalkanes can be added to petrol to improve the efficiency of combustion and eliminate knocking.	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Straight-chain alkanes can be isomerised to create branched-chain isomers and reformed into cycloalkanes which can be used as fuel additives.	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Long-chain hydrocarbons can be cracked to make smaller, more useful molecules. Shorter chain alkanes (used in fuels) and alkenes (used in polymers) are produced. **Students should be able to describe the reaction using an equation and with reference to the use of a catalyst (as well ass discussing economic considerations). Thermal cracking is explicitly mentioned in the AQA spec, and may be covered elsewhere.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**

Organic chemistry – polymers

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Amino acids can act as acids and bases and can form zwitterions	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Proteins are condensation polymers of amino acids which can undergo hydrolysis. **Students should be able to give details of the reaction (reagents, conditions), including the identification of peptide bonds in structures.**	**A2**	**X**	**A2**	**A2**	**X**	**X**
Proteins have different levels of structure. **More detailed structural knowledge required by CCEA and Salters. Salters also requires knowledge of the structure of DNA. Many students will be able to describe primary, secondary and tertiary structure in terms of the intermolecular forces involved.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Addition polymers are formed when many alkene monomers join together. **Students should be able to draw the polymer made from a specified monomer and vice versa. They should also be able to discuss the uses of polymers. CCEA needs LDPE and HDPE, salters and CCEA need branching crystalinity and properties**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Polymers with different properties have different uses. **Students should be able to relate the properties of polymers (e.g. LDPE, HDPE, PVC, PTFE, PS) to their uses.**	**X**	**A2**	**X**	**X**	**A2**	**A2**
Some alkenes form atactic, isotactic or syndiotactic polymers.	**X**	**X**	**X**	**A2**	**A2**	**X**
There are environmental consequences of the disposal of plastics.	**A2**	**A2**	**A2**	**A2**	**X**	**A2**
Condensation polymers are usually made from two different types of monomer. **Students should be able to describe the formation of polyamides (e.g. nylon) and polyesters (e.g. terylene) and give details of the reactions (reagents, conditions, mechanism). They should also be able to represent the polymers by showing repeat units.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Polyesters and polyamides are biodegradable because of the ease of hydrolysis of the links.	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**

Organic chemistry – halogenoalkanes

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Alkanes which contain halogen atoms are called halogenoalkanes (or haloalkanes). **Students should be able to name simple primary, secondary and tertiary halogenoalkanes and represent them using the different types of formulae discussed earlier.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
The rate of hydrolysis of halogenoalkanes depends on the halogen present. **Students should be able to describe the use of silver nitrate in the experiment and explain the results in terms of C-X bond strength.**	**AS**	**AS**	**AS**	**AS**	**X**	**X**

Organic chemistry – alcohols and their reactions

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Alcohols are organic molecules which contain –OH groups. **Students should be able to explain the high b.pts and water solubility of alcohols in terms of H-bonding + name and represent a range of primary, secondary & tertiary alcohols.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**

Organic chemistry – aromatic compounds

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Benzene and its derivatives are known as aromatic compounds. **Students should be able to recognise and name examples of aromatic compounds.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Benzene is a planar molecule with 6 delocalised π-electrons. **Students should be able to describe the structure/bonding in aromatic rings.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
The delocalised model of benzene is supported by experimental evidence. **Evidence includes bond lengths, enthalpy of hydrogenation and resistance to reaction.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**

Organic chemistry – aromatic compounds cont

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Phenols are a class or aromatic compound with –OH groups attached to the ring.	**X**	**A2**	**A2**	**A2**	**A2**	**X**
Phenols are acidic and have a range of useful applications **Students should be able to explain the properties of phenol as an acid in terms of the stabilisation of the anion.**	**X**	**X**	**A2**	**A2**	**A2**	**X**

Organic chemistry – amines and amides

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Amines contain the functional groups $-NH_2$, -NHR or NR_2. **Students should be able to recognise and name amines (including the use of primary, secondary and tertiary).**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Amines are basic. **Students should also be able to explain the basicity of amines due to their ability to accept a proton.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Azo dyes can be produced from amines in multi-step organic syntheses. **Students should be able to outline a synthesis and explain the colour of azo dyes.**	**X**	**X**	**X**	**A2**	**A2**	**A2**
Amides contain a carbonyl group bonded to a nitrogen atom. **Students should be aware of amides and their chemistry (OCR A teaches this only in the context of polyamides)**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**

Organic chemistry – more advanced principles

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
The synthesis of drugs often requires the production of a single enantiomer. **Students should be aware of the issues involved in chiral synthesis (OCR most detailed).**	**X**	**A2**	**A2**	**X**	**X**	**X**
Combinatorial chemistry has been used industrially to produce large numbers of compounds. **Students should be aware of the basic principles of combinatorial chemistry**	**X**	**A2**	**X**	**A2**	**X**	**X**
Bonding and structure affect the pharmacological activity of a compound. **Students should be able to describe and explain the structure and action of a given pharmacologically active compound.**	**X**	**X**	**X**	**A2**	**X**	**X**
Retrosynthesis can be used to devise organic syntheses. **Students should be aware of the term 'retrosynthesis', although coverage will be patchy and no more than rudimentary.**	**X**	**X**	**X**	**A2**	**X**	**X**

Physical chemistry – energetics and entropy

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Most chemical reactions have an enthalpy change associated with them. Exothermic reactions give out heat energy; endothermic reactions take heat energy in. **Students should be able to draw enthalpy profile diagrams with labels to illustrate exo- and endothermic reactions, showing ΔH and E_a. (understanding of the term enthalpy is often woolly)**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Enthalpy changes can be worked out using $\Delta H = mc\Delta T$. (q is used occasionally) **Students should be able to describe/plan experimental techniques to work out enthalpy changes, although changes to practical delivery/assessment may mean that these abilities are weaker than before.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Enthalpy changes can be worked out indirectly by applying Hess's Law. **Students should be able to draw enthalpy cycles to illustrate how they use enthalpy values to calculate enthalpy changes.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Breaking bonds is an endothermic process while making bonds is exothermic. **Students <u>may</u> be aware of the link between bond length and bond strength.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Born-Haber cycles can be used to show the relationship between the following enthalpy changes: formation, atomisation, ionisation (1st, 2nd etc), electron affinity (1st, 2nd etc), and lattice enthalpy. **Students should be able to define each enthalpy change and write an appropriate equation. Salters students know about Lattice enthalpies, but Born-Haber cycles are not covered.**	**A2**	**A2**	**A2**	**X**	**A2**	**A2**
Students can construct and use Born-Haber cycles (e.g to calculate lattice enthalpy)	**A2**	**X**	**A2**	**X**	**X**	**A2**
Students should be able to explain why theoretical lattice enthalpies differ from experimental values using ideas about polarised ions.	**A2**	**A2**	**X**	**X**	**X**	**X**
Students should be able to define enthalpy of solution and perform calculations.	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Students should be able to define enthalpy of hydration and perform calculations.	**A2**	**A2**	**A2**	**A2**	**A2**	**X**

Physical chemistry – energetics and entropy cont.

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Ionic charge and size affect the magnitude of lattice enthalpy.	**A2**	**X**	**A2**	**X**	**A2**	**A2**
Thermal decomposition of carbonates is affected by charge density.	**X**	**AS**	**AS**	**AS**	**X**	**AS**
Entropy is a measure of the disorder of a system. **Students should be able to give a qualitative description of the trend in entropy on going from solid → liquid → gas.**	**A2**	**A2**	**A2**	**AS**	**A2**	**A2**
Entropy changes can be calculated using the expression $\Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings}$ **Students should be able to perform appropriate calculations and use the results to explain chemical processes.**	**X**	**A2**	**X**	**A2**	**X**	**X**
The entropy change of the system, ΔS_{system}, (or the standard entropy change ΔS) can be calculated from the appropriate data	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
The entropy change of the surroundings can be calculated using the expression $\Delta S_{surr} = -\Delta H/T$	**X**	**A2**	**X**	**A2**	**X**	**X**
Spontaneous change occurs when the total entropy change is positive. **Students should be able to calculate entropy changes given appropriate data, explaining why some endothermic reactions can occur spontaneously. Note that AQA, OCR A, WJEC & CCEA use Gibbs Free Energy (see below).**	**X**	**A2**	**X**	**A2**	**X**	**X**
The expression $\Delta G = \Delta H - T\Delta S$ is used to calculate free energy changes. **Students should be able to perform appropriate calculations and use the results to explain chemical processes**	**A2**	**X**	**A2**	**X**	**A2**	**A2**
Processes are spontaneous (feasible) when the free energy change is negative	**A2**	**X**	**A2**	**X**	**A2**	**A2**

AQA requires a discussion of why mean bond enthalpies may be unreliable in predicting ΔH of reactions this is still in. **Edexcel** requires a rationalisation of the solubilities of hydroxides and sulphates of group 2 metals in terms of lattice and hydration enthalpies. **Salters** requires an explanation of the solubilities of ionic and covalent substances in solvents of differing polarity.

Physical chemistry - kinetics

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Particles must collide to react. **Students should be able to describe and explain the effect on rate of reaction of changing concentration, pressure and surface area. They should be able to explain what is meant by activation energy using an enthalpy profile diagram & making reference to bond breaking.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Molecules in a gas possess a range of different kinetic energies and increasing the temperature leads to an increase in average KE and the proportion of molecules with >= E_a. **Students should be able to sketch a Boltzmann distribution and use this to help explain the effect of increasing T on the reaction rate.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Catalysts increase the rate of reaction by providing an alternative reaction pathway with a lower activation energy while remaining unchanged at the end of the reaction. **Students should be able to use enthalpy profile diagrams and Boltzmann distributions to explain how catalysts speed up reactions.**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Students should be able define and use the following terms: rate of reaction, rate constant and order of reaction.	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Students should be able to define and use the term half life	**X**	**A2**	**A2**	**A2**	**A2**	**X**
Initial rates can be taken using tangents in graphs of concentration vs time. **Students should be able to deduce the rate equation rate = $k[A]^m[B]^n$ using initial rate data (limited to m/n = 0,1 or 2) and calculate the rate constant from given data.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Students should be able to explain qualitatively the effect of changes in temperature on the rate constant.	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Students should be able to use kinetic data to propose steps in reaction mechanisms. Note that only Edexcel and CCEA cover S_N1 and S_N2 specifically.	**X**	**A2**	**A2**	**A2**	**A2**	**A2**

Physical chemistry – kinetics cont.

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
The slowest step in a multi-step reaction is the rate-determining step. **Students should be able to propose a rate equation that is consistent with the rate-determining step.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Homogeneous catalysts are in the same phase as reactants and work by forming intermediates.	**A2**	**A2**	**X***	**A2**	**AS**	**X**
Homogeneous catalysis is demonstrated by the breakdown of atmospheric ozone as catalysed by Cl formed during the breakdown of CFCs by uv light. **Students should be able to write equations to show the breakdown of ozone.**	**AS**	**AS**	**AS***	**AS**	**X**	**X**
Catalysts can be poisoned which prevents them from working.	**A2**	**X**	**X**	**A2**	**X**	**AS**
Heterogeneous catalysts are in a different phase from the reactants. Bonds in reactants are weakened when they are adsorbed on the surface. OCR A only touch on the subject mentioning catalytic converters at AS level. **Students should be able to explain the application of a heterogeneous catalyst e.g. Fe in Haber process, Pt/Rh in catalytic converter.**	**A2**	**A2**	**AS***	**A2**	**A2**	**A2**

*Note that **OCR** doesn't make any mention of the terms heterogeneous and homogeneous with regard to catalysis, although examples of both are studied (e.g. heterogeneous: catalytic converter, homogeneous: acid catalysed esterification). Similarly, **CCEA** covers the concept of heterogenous catalysis, but examples of both forms are taught.

Physical chemistry - equilibria

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Reversible reactions can reach dynamic equilibrium. **Students should be able to state the features of a dynamic equilibrium and use Le Chatelier's principle to predict the effect on equilibrium position of changing c, P and T, as well as recalling that catalysts have no effect on equilibrium position (expanded on at A2 – see below).**	**AS**	**AS**	**AS**	**AS**	**AS**	**AS**
Careful consideration is given to the conditions used for industrial processes involving equilibria. **Students should be able to explain the compromises that are made regarding temperature and pressure with reference to yield and rate of reaction.**	**AS**	**A2**	**AS**	**A2**	**(X)**	**AS**
K_c is the equilibrium constant in terms of concentration. **Students should be able to write an expression for K_c from the balanced symbol equation and give the units and carry out calculations using given data.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
The total pressure is equal to the sum of the partial pressures.	**X**	**A2**	**X**	**X**	**A2**	**A2**
Partial pressures can be calculated from the total pressure and mole fractions.	**X**	**A2**	**X**	**X**	**A2**	**A2**
K_p is the equilibrium constant in terms of partial pressure. **Students should be able to write an expression for K_p from the balanced symbol equation and give the units and carry out calculations using given data.**	**X**	**A2**	**X**	**X**	**A2**	**A2**
Le Chatelier's Principle helps predict the effect of changing the conditions of an equilibrium. **Students should be able to explain the shift in equilibrium position resulting from changes in macroscopic properties (from AS) <u>and</u> explain the effect of temperature changes on the value of K_c / K_p in relation to the sign of ΔH.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Students should recall that although changes in concentration (pressure) will affect the equilibrium position, they have no effect on the value of K_c (K_p).	**X**	**X**	**A2**	**X**	**X**	**A2**

Edexcel requires the ability to deal with heterogeneous equilibria as well. CCEA requires knowledge of partition coefficients.

Physical chemistry - acids & bases

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Acids are proton donors and bases are proton acceptors. Note that **OCR** and **WJEC** cover some of this material at AS level, overall the subject is spread over both levels. **Students should be able to identify acid-base reactions from symbol equations and describe the reaction of acids with metals, carbonates and alkalis.**	**A2**	**A2**	**AS**	**A2**	**AS**	**A2**
Strong acids/bases are fully dissociated in aqueous solutions while weak acids/bases are only partially dissociated. **Students should be able to explain the difference between strong acids and concentrated acids.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Acids and bases form conjugate acid-base pairs. **Students should be able to identify conjugate acids and bases.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
The pH scale can be used as a measure of $[H^+]$ concentration. **Students should be able to calculate the pH of a strong acid from its concentration.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
K_a is the acid dissociation constant. **Students should be able to:** **write an expression for K_a.** **calculate K_a or [HA] from given data.** **Work out $[H^+]$ and consequently estimate pH of a weak acid (without using quadratic equations)**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
pK_a is $-\log_{10}K_a$. **Students should be able to work out pK_a values and explain their significance.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
K_w is the ionic product of water and can be used to calculate $[H^+]$ and pH of alkaline solutions.	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**

K_b is not specified by any of the exam boards however may still be taught as a legacy of former content.

Physical chemistry - acids & bases cont.

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
pH curves show how pH changes in the course of a titration. **Students should be able to sketch approximate pH curves for a given acid-base titration and select an appropriate indicator with reference to the curve.**	**A2**	**A2**	**A2**	**X**	**A2**	**A2**
Students should be able to work out pK_a from the half-equivalence point in a pH curve.	**X**	**A2**	**X**	**X**	**X**	**X**
Buffers are solutions which minimise changes in pH when small amounts of acid/alkali are added. **Students should be able to give examples of acidic and basic buffers and explain in terms of equilibria shifts how they minimise changes in pH. Students should also be able to calculate the pH of a buffer solution.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Buffers play an important role in biological and non-biological systems. **Examples could include shampoo and blood.**	**A2**	**A2**	**A2**	**A2**	**X**	**X**

AQA requires this knowledge to be applied to diprotic/dibasic acids and bases. **OCR A** requires knowledge of the enthalpy of neutralisation. Both CCEA and WJEC require students to be able to predict the pH of a solution of a salt.

Physical chemistry - electrochemistry

Topic	AQA	Ed	OCR	OCR Salters	WJEC	CCEA
Electrochemical cells are made from two different metals dipped in salt solutions of their own ions. **Students should be able to draw labelled diagrams to show electrochemical cells and use *E*° values to indicate which metal is oxidised.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
The standard hydrogen electrode can be used as a reference electrode to measure standard potentials of other half-cells.	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
The electrochemical series can be used to explain the reactivity of metals in terms of oxidising/reducing powers of elements/ions. **Students should be able to predict whether or not a reaction will occur on the basis of *E*° values and explain why there may be exceptions to these predictions.**	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**
Rusting is due to electrochemical processes involving iron, water and oxygen. **Students should be able to write relevant equations, as well as describing methods of preventing rust (giving appropriate electrochemical explanations).**	**X**	**X**	**X**	**A2**	**X**	**X**
Electrochemical cells can be used as a potential energy source	**A2**	**A2**	**A2**	**A2**	**A2**	**X**
The hydrogen fuel cell can be used as an energy source **Students should be able to describe the electrochemical processes occurring in the fuel cell. Coverage in the different specifications is variable, with OCR A particularly extensive.**	**A2**	**A2**	**A2**	**X**	**A2**	**X**
Standard electrode potentials can be used to make predictions regarding the feasibility of chemical reactions. There are limitations in the application of this approach	**A2**	**A2**	**A2**	**A2**	**A2**	**A2**

Edexcel need fuel cells as breathalysers and E_{cell}, ΔS and equilibrium constants. **Salters** need to know about redox processes in the nitrogen cycle

Appendix A: Links to A-level specifications:

AQA: http://web.aqa.org.uk/qual/gce/pdf/AQA-2420-W-SP.PDF

Edexcel: http://www.edexcel.com/migrationdocuments/GCE%20New%20GCE/UA024832%20GCE%20in%20Chemistry%20Issue%204%20250510.pdf

OCR A: http://www.ocr.org.uk/download/kd/ocr_9910_kd_gce_spec.pdf

OCR Salters: http://www.ocr.org.uk/download/kd/ocr_10070_kd_l_gce_spec.pdf

WJEC: http://www.wjec.co.uk/uploads/publications/6148.pdf

CCEA: http://www.rewardinglearning.org.uk/qualifications/results.aspx?g=1&t=1&c=R&s=12&v=0&f=0&q=177&d=d

Alternative post-16 qualifications

Increasing numbers of students are arriving at university with alternative qualifications, most notably the IB which has been adopted by a number of 6th form colleges and schools where it is typically run alongside traditional A-levels. Students at such institutions have the choice of which pathway to take. The IB has also been adopted by a number of independent schools. One of the key virtues of the IB is the fact that it helps to foster a spirit of responsibility for their own learning in the minds of the students, and it encourages them to think more about how they learn. A full review of the subject content of the IB hasn't been done here, but it appears that the volume of content is at least on a par with A-level in most areas, and indeed goes beyond A-level in a number of key areas. The Cambridge Pre-U is another qualification which has appeared on admissions tutors' radars this year. An inspection of the 2010 examination papers indicates that this is a highly challenging qualification that not only stretches the most able students, but differentiates very well between the highest performers with three grades of distinction sitting above 3 grades of merit. D3 equates to an A, D2 to an A*, so goodness knows what conclusion we draw about a student with D1! An inspection of the content shows that this is on a par with the content of A-level from at least as far back as c.1993 (when I did it!).

David Read August 2010

Appendix B: Forming a picture of the 2010 Chemistry Undergrad

A summary of discussions which took place between academics and teachers during our annual Post-16 Teachers day on 10/06/2010

On June 10th 2010, we hosted over 30 teachers from local schools and colleges. 10 of our own academics and teaching staff attended and were joined by a few staff from the chemistry departments at Oxford and Reading universities. The bulk of the teachers came from Post-16 colleges (there are very few 11-18 schools in Hants). We went to great lengths to bring in colleagues from 11-18 schools, and a few staff attended from comprehensives and grammar schools, as well as a teacher from an independent 11-18 school in Southampton.

We set the scene with an introductory talk on the rationale behind the original changes to GCSE (2006) and A-level (2008) which students arriving at university in 2010 will have taken. The main focus of the morning was a discussion session where 6 breakout groups of ~7 individuals (a mixture of teachers and university staff) were placed in each group.

Each group was given a proforma with questions to direct the discussion, and a scribe was asked to note any key points that were made. This document pulls together the comments from these proformas. Note that the contents are pretty raw in their form, and are in no way endorsed by the University of Southampton, nor do they necessarily reflect the views of the 'average' chemistry teacher. Having said that, we do believe that the large cohort who attended on the day give us a broad spectrum of views.

As we have stated elsewhere, perceived declining standards and our remarks about these can only have a negative impact on our students. There can be no question that the content of A-level chemistry has been eroded by successive revisions beginning in about 1995, and as such most students have been exposed to less chemistry than in the past. However, many are far more resourceful than we give them credit for, and with appropriate support more of them are capable of excelling than we realise. After all, it isn't their fault that the exam system they have been through is perhaps not actually fit for purpose.

David Read August 2010

What will be the key differences in our 2010 entrants? (practical skills, problem-solving, mathematical competence, independence etc.)

- Practical skills reduced significantly
- Problem solving reduced
- Rote learning prevents application to abstract problems
- No experimental/investigation planning in all specifications other than OCR Salters
- Practical manipulation ok but poor 'planning from scratch' skills
- Poor observational skills
- Practical assessments done now are very prescriptive with only short answers, answering set questions
- Format of practical encourages concise yet specific observations using technical vocabulary (which is +ve)
- Difference between Salters and other courses – effect of individual investigations –very good preparation for uni style work
- Much less independent learning
- Fewer opportunities to practice mathematical skills/Math skills similar graphing skills worse/Weaker maths skills

Having taught the whole of A-level, what's the teachers' view of the impact of the new specifications?

Negatives

- AQA has decreased content
- OCR A – some content removed, lacking in organic (no C-C bond forming reactions!)
- Teaching strongly linked to a single textbook which is often used in lessons and for homework (i.e. students lack research skills)
- AQA practical assessment (ISA) is not a learning experience
- Change in exam timing (earlier in year) adds extra pressure
- Most students lack an enquiring mind

Positives:

- OCR Salters shows very little change
- A2 more enjoyable due to reduction of content
- More ethical concepts
- More green chemistry
- More thorough mechanisms
- Better exam questions for stretch and challenge
- More IT/ multimedia resources to illustrate concepts
- Move to develop more 'thinking style' questions like Salters

Do you have any specific examples of gaps we should expect in students' background knowledge in October?

- Some specs have reduced their coverage of organic reactions, but this is variable.
- Some specs only cover K_c **not** K_p
- Born-Haber cycles no longer constructed by all students
- K_{sp} no longer covered by Salters (hasn't been covered by others for years)
- OCR A no longer covers the reasons for the colour of TM complexes.
- Report writing skills, use of scientific language
- Coverage of mechanisms is patchier.
- Salters and Edexcel don't cover Gibbs free energy (the others all do), preferring to focus on a treatment of total entropy.

What can we expect the students to be better at (let's be positive for once!)?

- Use of knowledge across two subjects (biology and chemistry, chemistry and maths) – ***but how widespread?***
- IT competence is good
- Use of curly arrows may well be better – some teachers reported that students have shown better ability to apply mechanistic principles to other contexts (may not be the case across the board, though).

- Ethical and green chemistry is covered in most specifications, and students have been taught more about the 'scientific process' and its relation to economic and social concerns.
- Following instructions in practicals (to the detriment of independent thinking, though).
- All students will have covered entropy for the first time in a few years.

How have the new GCSEs impacted upon students ability to succeed at AS and then A2?

- National grades for GCSE went up – students feel 'entitled' to higher grades at A-level.
- Individual exam boards' GCSE specs prepare students well for that exam boards' A-levels (doesn't help students who change exam boards when going to A-level).
- Some specifications such as 21st century science are poor preparation for A-level (***controversial***!).
- General knowledge of study skills reduced. This includes comprehension and structuring of answer.
- Reduced ability to tackle longer questions.
- New GCSEs have more data analysis questions.
- A2 not impacted (assuming hard work at AS, and loss of weakest students before A2).
- A mix of ability at start of Y12 requires normalisation period.
- There is a mentality that re sits are acceptable.
- Way too much 'spoon-feeding' at GCSE.
- Transition to AS level shocks students leading to a wave of drop outs, others get lower grades than expected
- Quality of GCSE maths has had a significant detrimental effect

Have you changed your teaching to take account of 'Stretch and Challenge'? Will there be specific differences in the capabilities high flyers? (what about not-so-high flyers?)

- Continue to teach old specification ideas and concepts which are challenging
- Use of unknown molecules in problems to stretch students.
- Salters good as individual study required for A2 practical project.
- Some students entered for short course about molecules and medicine self study with the OU (could be done as EPQ).
- Little has changed because stretch and challenge has always been there in a way
- No! But we are doing the EPQ, however
- More problem based learning
- need to do more than just spout chemistry theory
- Give them demanding exam questions

Do you have suggestions for strategies that university chemistry departments can adopt to support the 2010 cohort?

- Working alongside schools/colleges regularly
- Dialogue between KS5 and university staff
- Maths for chemists support even for students with A-level maths (compulsory)
- Consider how info is provided not all paper based
- Identify the students need early on
- let them know what's expected for long answers questions
- Make them plan an investigation