

Scheme of Work

Cambridge International AS & A Level Chemistry 9701

For examination from 2016

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Introduction

This scheme of work has been designed to support you in your teaching and lesson planning. Making full use of this scheme of work will help you to improve both your teaching and your learners' potential. It is important to have a scheme of work in place in order for you to guarantee that the syllabus is covered fully. You can choose what approach to take and you know the nature of your institution and the levels of ability of your learners. What follows is just one possible approach you could take and you should always check the syllabus for the content of your course.

Suggestions for independent study (**I**) and formative assessment (**F**) are also included. Opportunities for differentiation are indicated as **Extension activities**; there is the potential for differentiation by resource, grouping, expected level of outcome, and degree of support by teacher, throughout the scheme of work. Timings for activities and feedback are left to the judgment of the teacher, according to the level of the learners and size of the class. Length of time allocated to a task is another possible area for differentiation.

Key concepts

The key concepts on which the syllabus is built are set out below. These key concepts can help teachers think about how to approach each topic in order to encourage learners to make links between topics and develop a deep overall understanding of the subject. As a teacher, you will refer to these concepts again and again to help unify the subject and make sense of it. If mastered, learners can use the concepts to solve problems or to understand unfamiliar subject-related material.

KC1 – Atoms and forces

Matter is built from atoms interacting and bonding through electrostatic forces. The structure of matter affects its physical and chemical properties, and influences how substances react chemically.

KC2 – Experiments and evidence

Chemists use evidence gained from observations and experiments to build models and theories of the structure and reactivity of materials.

KC3 – Patterns in chemical behaviour and reactions

By identifying patterns in chemical behaviour we can predict the properties of substances and how they can be transformed into new substances by chemical reactions. This allows us to design new materials of use to society.

KC4 – Chemical bonds

The understanding of how chemical bonds are made and broken by the movement of electrons allows us to predict patterns of reactivity.

KC5 – Energy changes

The energy changes that take place during chemical reactions can be used to predict both the extent and the rate of such reactions.

The key concepts are listed under the relevant syllabus reference, those in **bold** are where the coverage of the learning objective makes a significant contribution to the key concept

Guided learning hours

Guided learning hours give an indication of the amount of contact time teachers need to have with learners to deliver a particular course. Our syllabuses are designed around 180 hours for Cambridge International AS Level, and 360 hours for Cambridge International A Level. The number of hours may vary depending on local practice and your learners' previous experience of the subject. The table below give some guidance about how many hours are recommended for each topic.

Topic	Suggested teaching time (%)	Suggested teaching order
AS Level		
1: Particles	It is recommended that this unit should take about 25 hours/ 7% of the course.	2.1.a, 2.1.b, 2.1.c, 2.1.d, 2.2.a, 2.2.b, 2.2.c, 1.1.a, 2.3.a, 2.3.b, 2.3.c, 1.2.a, 1.3.a, 1.3.b, 1.4.a, 1.4.b, 1.5.a, 1.5.b, 1.5.c
2: Bonding and structure	It is recommended that this unit should take about 25 hours/ 7% of the course.	3.1.a, 3.2.a, 3.2.c, 3.2.b, 3.2.d, 14.3.a, 3.4.a, 4.3.a, 4.2.a, 4.1.a, 4.1.b, 4.1.c, 3.5.a, 3.3.b, 3.3.d, 3.3.a, 3.5.b, 4.3.d, 4.3.c, 4.3.b
3: Controlling reactions 1	It is recommended that this unit should take about 36 hours/ 10% of the course.	5.1.a, 3.5.c, 3.3.c, 5.1.b (i) and (ii) only, 5.1.c, 5.2.a (i) & (ii) only, 15.3.a, 15.3.b, 13.2.a, 13.2.b, 15.3.c, 6.1.a, 6.1.b, 6.1.c, 8.1.a, 8.1.b, 5.2.b, 8.3.a, 8.3.b, 8.3.c, 8.3.d, 8.2.a, 8.2.b, 7.1.a, 7.1.b, 7.1.c, 7.1.d, 7.1.e, 7.1.f, 7.1.g, 7.2.a, 7.2.b
4: Organic chemistry 1	It is recommended that this unit should take about 54 hours/ 15% of the course.	14.1.a (AS only), 14.1.b, 14.1.d, 14.1.e, 14.2.a, 15.1.a, 15.1.b, 15.1.c, 15.1.d, 15.1.e, 15.2.a, 15.2.b, 15.2.c, 15.2.d, 15.2.e, 15.2.f, 15.2.g, 22.2.a, 14.4.a, 14.4.b, 14.4.c, 14.4.d, 14.4.e, 16.1.a, 16.1.b, 16.1.c, 16.2.a, 16.2.b, 16.2.c, 17.1.a (i) to (vi) only, 17.1.b, 17.1.c, 18.1.a, 18.1.b, 18.1.c, 18.1.d, 18.1.e, 19.1.a, 19.1.b (i) to (iii) only, 19.3.a, 19.3.b
5: Chemical trends	It is recommended that this unit should take about 40 hours/ 11% of the course.	9.1.a, 9.1.b, 9.1.c, 2.3.d, 9.1.d, 2.3.e, 2.3.f, 9.2.a, 9.2.b, 9.2.c, 9.2.d, 9.2.e, 9.2.f, 9.2.g, 9.1.e, 9.3.a, 9.3.b, 10.1.a, 10.1.b, 10.1.c, 10.1.d, 10.1.e, 10.2.a, 11.1.a, 11.1.b, 11.2.a, 11.2.b, 11.2.c, 11.3.a, 11.4.a, 11.5.a, 11.5.b, 13.1.a, 13.1.b, 13.1.c, 13.1.d, 13.1.e, 13.1.f

Topic	Suggested teaching time (%)	Suggested teaching order
A Level		
6: Acids and bases	It is recommended that this unit should take about 18 hours/ 5% of the course.	7.2.c, 7.2.d, 7.2.e, 7.2.f, 7.2.g, 7.2.h, 7.2.i, 7.2.j, 7.2.k
7: Electricity and metals	It is recommended that this unit should take about 46 hours/ 13% of the course.	6.2.a, 6.2.b, 6.2.c, 6.2.d, 6.3.a, 6.3.b, 6.3.c, 6.3.d, 6.3.e, 6.3.f, 6.3.g, 12.2.d, 12.2.e, 6.3.h, 6.3.i, 6.4.a, 12.1.a, 12.1.b, 12.1.c, 12.1.d, 12.1.e, 12.1.f, 12.2.a, 12.2.b, 12.2.c, 12.3.a, 12.3.b, 12.3.c, 12.3.d, 12.5.a, 12.5.b, 12.5.c, 12.5.d
8: Controlling reactions 2	It is recommended that this unit should take about 29 hours/ 8% of the course.	5.1.b (iii) only, 2.3.g, 5.1.d, 5.2.a (iii) & (iv) only, 10.1.f, 10.1.g, 5.3.a, 5.3.b, 5.3.c, 5.3.d, 5.4.a, 5.4.b, 5.4.c, 5.4.d, 8.1.c, 8.1.d, 8.1.e, 8.1.f, 8.1.g, 8.1.h, 8.2.c
9: Organic chemistry 2	It is recommended that this unit should take about 65 hours/ 18% of the course.	14.1.a (AL only), 15.4.a, 15.4.b, 15.4.c, 15.4.d, 15.4.e, 14.1.c, 17.2.a, 17.2.b, 19.1.b (iv) only, 19.1.c, 19.1.d, 19.1.e, 19.2.a, 19.2.b, 17.1.a (vii) only, 19.2.c, 20.1.a, 20.1.b, 20.1.c, 20.1.d, 20.1.e, 20.2.a, 20.2.b, 20.2.c, 20.3.a, 20.3.b, 20.3.c, 8.3.e, 23.1.a, 23.1.b, 12.4.a, 12.4.b, 21.1.a, 21.1.b, 21.1.c, 21.1.d, 21.2.a, 21.2.b, 21.3.a, 21.3.b, 21.3.c, 21.4.a, 21.4.b, 21.4.c, 21.4.d, 23.2.a, 23.2.b, 23.2.c, 21.3.d, 21.3.e
10: Analysis	It is recommended that this unit should take about 22 hours/ 6% of the course.	22.3.a, 22.3.b, 22.3.c, 22.3.d, 22.1.a, 22.1.b, 7.3.a, 22.4.a, 22.4.b, 22.5.a, 22.5.b, 22.5.c, 22.5.d, 22.5.e

Resources

The up-to-date resource list for this syllabus, including textbooks endorsed by Cambridge International, is listed at www.cambridgeinternational.org. Endorsed textbooks have been written to be closely aligned to the syllabus they support, and have been through a detailed quality assurance process. As such, all textbooks endorsed by Cambridge International for this syllabus are the ideal resource to be used alongside this scheme of work as they cover each learning objective.

School Support Hub

The School Support Hub www.cambridgeinternational.org/support is a secure online resource bank and community forum for Cambridge teachers, where you can download specimen and past question papers, mark schemes and other resources. We also offer online and face-to-face training; details of forthcoming training opportunities are posted online. This scheme of work is available as PDF and an editable version in Microsoft Word format; both are available on the School Support Hub at www.cambridgeinternational.org/support. If you are unable to use Microsoft Word you can download Open Office free of charge from www.openoffice.org.

Websites

This scheme of work includes website links providing direct access to internet resources. Cambridge Assessment International Education is not responsible for the accuracy or content of information contained in these sites. The inclusion of a link to an external website should not be understood to be an endorsement of that website or the site's owners (or their products/services).

The website pages referenced in this scheme of work were selected when the scheme of work was produced. Other aspects of the sites were not checked and only the particular resources are recommended.

How to get the most out of this scheme of work – integrating syllabus content, skills and teaching strategies

We have written this scheme of work for the Cambridge International AS & A Level Chemistry (9701) syllabus and it provides some ideas and suggestions of how to cover the content of the syllabus. We have designed the following features to help guide you through your course.

Learning objectives help your learners by making it clear the knowledge they are trying to build. Pass these on to your learners by expressing them as 'We are learning to / about...'.

Suggested teaching activities give you lots of ideas about how you can present learners with new information without teacher talk or videos. Try more active methods which get your learners motivated and practising new skills.

Extension activities provide your abler learners with further challenge beyond the basic content of the course. Innovation and independent learning are the basis of these activities.

Independent study (I) gives your learners the opportunity to develop their own ideas and understanding with direct input from you.

Syllabus ref.	Learning objectives	Suggested teaching activities
KC4 / KC5 17.1b	(i) classify hydroxy compounds into primary, secondary and tertiary alcohols mild	<ul style="list-style-type: none"> Learners make molecular models of isomers of alcohols with 3, 4 and 5 carbon atoms. Learners practise naming them (LO 14.1.a iii, b and 14.4.a). Learners group them according to their structure. Some will group them as primary, secondary and tertiary and so you can use these to explain this idea. Learners discuss in groups – what might be the products of each group after oxidation? Learners research what the products of these oxidations would be with potassium dichromate(VI). Provide worksheets with examples of primary, secondary and tertiary alcohols. Learners must <ul style="list-style-type: none"> decide which can be oxidised and which cannot name a suitable oxidising agent give visible observations state conditions and give formulae of products. (I) Extension activity: construct balanced chemical equations. (I) Peer-marking exercise using mark scheme prepared by you. <p>http://www.rsc.org/learn-chemistry/resource/res00000588/three-isomeric-alcohols</p>
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support (F)		

Past Papers, Specimen Papers and Mark Schemes are available for you to download at:
www.cambridgeinternational.org/support

Using these resources with your learners allows you to check their progress and give them confidence and understanding.

Formative assessment (F) is on-going assessment which informs you about the progress of your learners. Don't forget to leave time to review what your learners have learnt, you could try question and answer, tests, quizzes, 'mind maps', or 'concept maps'. These kinds of activities can be found in the scheme of work.

1: Particles

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC1 2.1a	Identify and describe protons, neutrons and electrons in terms of their relative charges and relative masses.	<ul style="list-style-type: none"> Recap of IGCSE / O Level knowledge. Quick quiz on all of the LOs 2.1.a, 2.1.c, 2.1.d and 2.2.a. <ul style="list-style-type: none"> Learners create a presentation explaining the material in these four LOs. <p>Provide question sheet to assess appropriate knowledge level achieved. (I)</p> <p>http://www.s-cool.co.uk/a-level/chemistry (atomic structure) www.rsc.org/learn-chemistry/resource/res00001100/an-analogy-for-the-atom</p>
KC1 2.1b	Deduce the behaviour of beams of protons, neutrons and electrons in electric fields.	<ul style="list-style-type: none"> Demonstration experiment of electrons from a cathode ray tube being deflected by an electric field. <ul style="list-style-type: none"> Invite learners to prepare this practical with you and perform demonstration. (I) Learners taking A Level Physics offered the opportunity to prepare and deliver explanation. (I) Watch video clip of this practical on the internet. Learners read about the behaviour of the different particle types. (I) You lead Q&A to assess knowledge gained. <p>Provide two levels of worksheet to practise questions about this. (I)</p> <p>www.youtube.com/watch?v=m92QR7CBNoQ www.youtube.com/watch?v=PpOAlj7sOEc</p>
KC1 2.1c	Describe the distribution of mass and charge within an atom.	<ul style="list-style-type: none"> Learners make 3-D models of atoms, using dried peas / lentils / beans etc. Use different coloured pulses to represent each particle type. <ul style="list-style-type: none"> Extend to make models of isotopes such as chlorine 35 and chlorine 37 and linked to LO 2.2.b. <p>Provide worksheets (with mark scheme) of practice questions. (I)</p>
KC1 2.1d	Deduce the numbers of protons, neutrons and electrons present in both atoms and ions given proton and nucleon numbers and charge.	<ul style="list-style-type: none"> Peer-marking of practice questions (from 2.1.c). Requires detailed mark schemes prepared by you. <p>Include feedback time for pairs of learners to explain the award and non-award of specific marks.</p>

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC1 2.2a	Describe the contribution of protons and neutrons to atomic nuclei in terms of proton number and nucleon number.	<ul style="list-style-type: none"> Recap of IGCSE knowledge. Quick quiz on atomic number and mass number. Examples of sections of questions from past exam papers 1 and 2. Concepts of atomic number and mass number applied to 3D models of atoms made in previous lesson.
KC1 2.2b	Distinguish between isotopes on the basis of different numbers of neutrons present.	<ul style="list-style-type: none"> Reinforcement activities on isotopes <ul style="list-style-type: none"> You teach the definition. Learners practise the definition in pairs. Possible creation of mnemonic sentences. (I) Concept of isotopes applied to 3-D models of atoms made in previous lesson. Provide worksheets (with mark scheme) listing composition of twenty different atoms, learners have to group together those that are isotopes of a particular element. (I)
KC1 2.2c	Recognise and use the symbolism ${}^x_y\text{A}$ for isotopes, where x is the nucleon number and y is the proton number.	<ul style="list-style-type: none"> Provide worksheets (with mark scheme) of various elements shown in the conventional way, e.g. ${}^{23}_{11}\text{Na}$. <ul style="list-style-type: none"> Worksheet has blank columns for numbers of protons, neutrons and electrons. Learners complete the blank columns. Learners return to worksheet from 2.2b and apply conventional notation, e.g. ${}^{23}_{11}\text{Na}$ to each atom.
KC1 1.1a	Define and use the terms <i>relative atomic</i> , <i>isotopic</i> , <i>molecular</i> and <i>formula masses</i> , based on the ${}^{12}\text{C}$ scale.	<ul style="list-style-type: none"> Provide worksheets (with mark scheme) where learners must match a definition to each of the terms <i>relative atomic mass</i>, <i>isotopic mass</i>, <i>molecular mass</i> and <i>formula mass</i>. (I) Paired exercise to learn these terms. Creation of mnemonic exercises to learn these terms. (I) You and learners put in your planners/diaries three occasions this academic year when these definitions (to include isotopes definition) will be tested and when they must be word perfect. Practical work to provide a context for this topic such as determining experimentally the relative atomic mass of, for example, magnesium. A description of such an experiment is in RSC 2000, experiment 17. Provide worksheets (with mark scheme) to practise relative molecular and formula mass calculations. (I) <p>http://www.rsc.org/learn-chemistry/resource/res00000401/the-determination-of-relative-atomic-mass</p>
KC1 2.3a	Describe the number and relative energies of the s, p and d orbitals for the	<ul style="list-style-type: none"> Learners recall and recap their IGCSE knowledge, they are asked to show electronic configuration of C, Na and Cl <ul style="list-style-type: none"> using numbers e.g. 2.8.1 for Na

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	principal quantum numbers 1, 2 and 3 and also the 4s and 4p orbitals.	<ul style="list-style-type: none"> ○ as a 'crosses on circles (shells)' diagram. (I) ● You then explain how each of the shells are made up of s, p and d orbitals. <p>Mini whiteboards can be used here. You can make these by laminating a piece of white card or white paper onto a piece of hardboard.</p>
KC1 2.3b	Describe and sketch the shapes of s and p orbitals.	<ul style="list-style-type: none"> ● Learners make models of s and p orbitals using balloons. They should use: <ul style="list-style-type: none"> ○ 1 balloon per s orbital ○ 2 balloons, joined at their 'knots' per p orbital ○ 3 (different coloured) pairs make one subshell of p orbitals. <p>http://www.youtube.com/watch?v=Ewf7RIVNBSA</p>
KC1 2.3c	State the electronic configuration of atoms and ions given the proton number and charge, using the convention $1s^2 2s^2 2p^6$, etc.	<ul style="list-style-type: none"> ● You explain how to use the notation $1s^2$, $2s^2$ etc. and how the three orbitals in p subshell are filled. ● Learners practise putting electrons into shells and subshells. Choice of: <ul style="list-style-type: none"> ○ 'Arrows in boxes' prepared worksheet ○ for the more kinaesthetic learners, placing physical 'counters' into boxes. Counters will need to have up and down orientations to show spin-pairing ● Learners use the notation $1s^2$, $2s^2$ etc. to describe each of the atoms they have just drawn/modelled/seen. (I) <p>www.youtube.com/watch?v=2AFPfg0Como http://www.kentchemistry.com/links/AtomicStructure/PauliHundsRule.htm</p>
KC1 1.2a	Define and use the term <i>mole</i> in terms of the Avogadro constant.	<ul style="list-style-type: none"> ● Learners carry out an experiment to determine Avogadro's constant by creating a 'monolayer' (Lainchbury experiment 1.1). ● Learners prepare a presentation for the rest of the class to show how to perform calculations and to determine the number of moles and number of particles present. <ul style="list-style-type: none"> ○ Learners write their own questions and explain to their peers how the answers are achieved. ● Provide worksheets (with mark scheme) of basic and more difficult questions. (I)
KC1 1.3a	Analyse mass spectra in terms of isotopic abundances (knowledge of the working of the	<ul style="list-style-type: none"> ● Possible visit to university department or an industrial company to see a mass spectrometer in action. ● Learners watch a video of a mass spectrometer in action. Learners do not need to know how a mass spectrometer works, but those who have an idea about how a mass spectrum is produced are more likely to gain deeper understanding of this topic, as are those who have some idea about what use mass spectra are put to in the 'real world'.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	mass spectrometer is not required).	<ul style="list-style-type: none"> Provide worksheets (with mark scheme) about mass spectra, with various examples (including some you may have obtained during your visit). You explain how to read the trace to determine the relative abundance of the different isotopes present. Learners practise reading mass spectra. (I) <p> http://www.youtube.com/watch?v=wyL7TRWAmzk http://webbook.nist.gov/cgi/cbook.cgi?Value=1+-+40&VType=MW&Formula=&AllowExtra=on&Units=SI&cMS=on Examples of mass spectra </p>
KC1 1.3b	Calculate the relative atomic mass of an element given the relative abundances of its isotopes, or its mass spectrum.	<ul style="list-style-type: none"> Learners discuss why chlorine is shown on the Periodic Table with a relative atomic mass of 35.5 (rather than a whole number). Each pair shares their discussion, (you may want to write them up on a flipchart, depending on the size of the class). Learners come to correct conclusion, possibly with your guidance. This activity is an important beginning of the <i>atoms and forces</i> key concept and is also linked to LO 2.2. You explain how to calculate relative atomic mass from mass spectra. Learners write a step-by-step method for how to calculate relative atomic mass from mass spectra. (I) Provide worksheets (with mark scheme) to practise some of these calculations. (I)
KC1 1.4a	Define and use the terms <i>empirical</i> and <i>molecular formula</i> .	<ul style="list-style-type: none"> Learners bring to this lesson every definition they can find of empirical and molecular formulae. They share them together and discuss <ul style="list-style-type: none"> which one(s) they think gives the most scientific definition the most easily understood definition the most concise definition. Learners decide on the same 'best' definition under your guidance. You and learners put in your planners/diaries three occasions this academic year when these definitions will be tested and when they must be word perfect. (I)
KC1 1.4b	Calculate empirical and molecular formulae, using combustion data or composition by mass.	<ul style="list-style-type: none"> You explain how to calculate empirical and molecular formulae from suitable data. Provide worksheets (with mark scheme) on calculating empirical and molecular formulae. Extend using past papers. (I) Learners also practise these calculations in Practical Booklet 1.
1.5a	Write and construct balanced equations.	<p>This LO continues what has been started at IGCSE and continues throughout the A Level course.</p> <ul style="list-style-type: none"> Learners create a step by step guide to writing equations, designed for learners in the early stages of the IGCSE course. <ul style="list-style-type: none"> The guides are shared to produce one guide the class agree is ideal. Learners share this with an IGCSE class where it's used to teach equation balancing.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
		<ul style="list-style-type: none"> • Provide worksheets (with mark scheme) on writing equations theoretically. (I) • Practical work such as Practical Booklet 1 gravimetric analysis. • This material will naturally be re-visited throughout the course. <p>Practical Booklets 1, 2, 3, 5</p>
1.5b	<p>Perform calculations, including use of the mole concept, involving:</p> <ul style="list-style-type: none"> (i) reacting masses (from formulae and equations) (ii) volumes of gases (e.g. in the burning of hydrocarbons) (iii) volumes and concentrations of solutions <p>When performing calculations, candidates' answers should reflect the number of significant figures given or asked for in the question. When rounding up or down, candidates should ensure that significant figures are neither lost unnecessarily nor used beyond what is justified (see also Practical Assessment, Paper 3, Display of calculation and reasoning).</p>	<p>Set all of this learning in a practical context.</p> <ul style="list-style-type: none"> • You demonstrate your titration method. • Learners produce method sheet which should include: <ul style="list-style-type: none"> ○ filling the burette ○ no air-bubble in burette spout ○ filling the pipette ○ no air-bubble in pipette tip ○ delivering from the pipette ○ delivering from the burette ○ desired accuracy (final drop). • Learners practise titration <ul style="list-style-type: none"> ○ This is an important part of preparing for Paper 3 ○ Start with a number of simpler acid-base titrations to start with such as HCl (aq) with NaOH (aq) (e.g. Hutchings, experiment 48 or Lainchbury experiment 1.3). ○ Extend to <ul style="list-style-type: none"> ▪ An I_2 (aq) with $\text{S}_2\text{O}_3^{2-}$ (aq) titration (such as Hill experiment 4), ▪ Aspirin with NaOH ▪ Fe^{2+} (aq) with $\text{H}^+/\text{MnO}_4^-$ (aq) ▪ The determination of a formula (e.g. x in hydrated magnesium sulfate, $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$, see Hill experiment 1, or in $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$ see Hutchings experiment 52). (I) • In order to prepare for Paper 3 you should perform the titration with your learners. Learners are aiming to: <ul style="list-style-type: none"> ○ Copy your technique ○ Copy your method of recording results ○ Achieve consistent (concordant) results ○ Match your results to $\pm 0.10 \text{ cm}^3$ • Practical booklets 2 and 3 will help learners with the (i) and (ii) parts of this LO. (I) • Learners practise AS practicals from past Paper 3 examples. (I) • Provide worksheets (with mark scheme) for learners to work through calculation problems in pairs and individually, creating method checklists to use for each type of calculation. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
		<p>Practical Booklets 2, 3</p> <p>http://www.rsc.org/learn-chemistry/resource/res00000697/titrating-sodium-hydroxide-with-hydrochloric-acid http://www.rsc.org/learn-chemistry/resource/res00000436/to-find-the-formula-of-hydrated-copper-ii-sulfate</p>
KC2 1.5c	Deduce stoichiometric relationships from calculations such as those in 1.5.b.	<p>This can be combined with LO 5.1.b</p> <ul style="list-style-type: none"> • Provide worksheets (with mark scheme) of data that allows deduction of stoichiometric relationships. (I) • Practical work that allows deduction of stoichiometric relationships, e.g. <ul style="list-style-type: none"> ○ NaOH (aq) with H₂SO₄ (aq) titration ○ Fe²⁺ (aq) with H⁺/MnO₄⁻ (aq) titration ○ HCl (aq) with Na₂CO₃ (aq) titration (I) <p>Pairs of learners are given a calculation problem that allows deduction of stoichiometric relationships. Each pair presents their solution.</p>
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support (F)		

2: Bonding and structure

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC4 3.1a	Describe ionic bonding, as in sodium chloride, magnesium oxide and calcium fluoride, including the use of 'dot-and-cross' diagrams.	<ul style="list-style-type: none"> Whole class recap of learners' knowledge of ionic bonding. <ul style="list-style-type: none"> each learner tells the rest of the class everything they know in 30 seconds successive learners must minimise repetition. (I) Provide worksheets (with mark scheme) for learners to complete 'dot and cross' diagrams for NaCl, MgO, CaCl₂. (I)
KC4 3.2a	Describe, including the use of 'dot-and-cross' diagrams: (i) covalent bonding, in molecules such as hydrogen, oxygen, chlorine, hydrogen chloride, carbon dioxide, methane, ethene (ii) co-ordinate (dative covalent) bonding, such as in the formation of the ammonium ion and in the Al ₂ Cl ₆ molecule.	<ul style="list-style-type: none"> Quick quiz on covalent bonding <ul style="list-style-type: none"> what a covalent bond is the types of atoms that form covalent bonds the difference(s) in covalent compared to ionic dot and cross diagrams for CH₄, H₂O, HCl. Learners practise 'dot and cross' diagrams to include both covalent and dative bonding C₂H₄, CO₂, NH₄⁺, CO, NO₃⁻, Al₂Cl₆. Provide helpsheet if needed.
KC4 3.2c	Explain the shapes of, and bond angles in, molecules by using the qualitative model of electron-pair repulsion (including lone pairs), using as simple	<ul style="list-style-type: none"> Learners use molecular model kits to make O₂, H₂O, CH₄, NH₃, SF₆, BF₃ and PF₅. You lead a discussion of the 3-D shapes of molecules. Be aware of difficulty in transfers between 2-D on paper to 3-D in the model, assess individual needs by Q&A. You explain VSEPR (valence shell - electron pair repulsion theory). Provide worksheets (with mark scheme) for learners to draw the shapes, number of pairs of electrons (split into bonding pairs and lone pairs), and the bond angle of various molecules. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	examples: BF_3 (trigonal), CO_2 (linear), CH_4 (tetrahedral), NH_3 (pyramidal), H_2O (non-linear), SF_6 (octahedral), PF_5 (trigonal bipyramidal).	<ul style="list-style-type: none"> ○ Assign each of the molecules on this worksheet to a pair of learners for them to prepare a presentation to the rest of the class explaining the shape and bond angle. ○ Peer-marking of presentations. Learners using mark scheme prepared by you. Mark scheme must include: <ul style="list-style-type: none"> ▪ Name of shape ▪ 3-D diagram ▪ Specific statement about bond pairs ▪ Specific statement about lone pairs ▪ Bond angle.
KC4 3.2b	Describe covalent bonding in terms of orbital overlap, giving σ and π bonds, including the concept of hybridisation to form sp , sp^2 and sp^3 orbitals (see also LO 14.3).	<ul style="list-style-type: none"> ● Find the balloon models of s and p orbitals that learners made in LO 2.3 b. ● You teach sp, sp^2, sp^3 hybridisation. ● You describe orbital overlap when covalent bonds form, <ul style="list-style-type: none"> ○ s and s, e.g. H_2 ○ s and hybrid, e.g. CH_4 ○ p and p, e.g. CH_2O, CO_2. ● For kinaesthetic learners the act of hybridisation and orbital overlap can be physically modelled using modelling clay (e.g. Plasticine or Blu-tack). ● Provide worksheets (with mark scheme) describing the hybridisation and drawing the 'shape of the orbital overlap' in H_2O, NH_3, C_2H_6, C_2H_4, CO. (I)
KC4 3.2d	Predict the shapes of, and bond angles in, molecules and ions analogous to those specified in 3.2.b (see also LO 14.3).	<ul style="list-style-type: none"> ● Learners create a checklist of the steps needed to predict the shape and bond angle (see LO 3.5.b) in unfamiliar molecules. ● Learners practise this skill with both basic and more challenging molecules. ● Provide worksheets (with mark scheme) of examples. (I)
KC4 14.3a	Predict the shapes of, and bond angles in, molecules and ions analogous to those specified in 3.2(b) (see also LO 14.3).	<ul style="list-style-type: none"> ● You remind learners of organic molecules encountered in 3.2.b particularly C_2H_6 and C_2H_4. ● Learners make molecular models of ethane, ethene and benzene (not required at AS but useful to include here) <ul style="list-style-type: none"> ○ use hybridisation to discuss bond angles in these molecules. ● look at some more organic molecules and apply these ideas to them.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC4 3.4a	Describe metallic bonding in terms of a lattice of positive ions surrounded by delocalised electrons.	<ul style="list-style-type: none"> You explain the components of a metallic lattice <ul style="list-style-type: none"> positive ions delocalised electrons attractive force between these particles type of lattice used to explain physical properties. Offer learners choice of: <ul style="list-style-type: none"> Poster work. For visual learners. Creation and recording of a dialogue between a sodium atom and its outer electron to describe what happens when the sodium atom comes together with many other sodium atoms, and why they subsequently stay together. For auditory learners. Model making. A high sided tray will be needed, cardboard discs can represent positive ions, lentils or dried peas can represent electrons. When the tray is moved quickly from side to side discs must stay still but lentils must move about. For kinaesthetic learners. Each activity is presented to the class. Other learners assess using mark scheme prepared by you. Provide worksheets explaining the melting points of sodium, magnesium, and aluminium. (I)
KC3 / KC4 / KC5 4.3a	Describe, in simple terms, the lattice structure of a crystalline solid which is: <ul style="list-style-type: none"> (i) ionic, as in sodium chloride, magnesium oxide (ii) simple molecular, as in iodine and the fullerene allotropes of carbon (C₆₀ and nanotubes only) (iii) giant molecular, as in silicon(IV) oxide and the graphite, diamond and graphene allotropes of carbon (iv) hydrogen-bonded, as in ice (v) metallic, as in copper. 	<ul style="list-style-type: none"> Learners making models of the four types of structure; ionic, simple molecular, giant molecular, and metallic Pairs or groups make one type each so that there is a class set. Provide worksheets about the properties of each of these solid structures. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC4 / KC5 4.2a	Describe, using a kinetic-molecular model, the liquid state, melting, vaporisation, vapour pressure.	<ul style="list-style-type: none"> Learners to create a page of diagrams to represent the particles in a liquid and how they change as a liquid changes state. (I) Practical work measuring the temperature change on forming solutions, e.g. Lainchbury Experiment 3.6. Practical work plotting the cooling curve of stearic acid, e.g. Hutchings Experiment 26. Learners discuss the changes on dissolving and melting using only the key concepts of <i>chemical bonds</i> and <i>energy changes</i>. <p> http://www.rsc.org/learn-chemistry/resource/res00000421/particles-in-motion http://www.rsc.org/learn-chemistry/resource/res00000390/the-energetics-of-freezing </p>
KC4 4.1a	State the basic assumptions of the kinetic theory as applied to an ideal gas.	<ul style="list-style-type: none"> Learners revisit IGCSE / O Level states of matter <ul style="list-style-type: none"> learners physically act out or 'become' particles in a role-play in each of the states. ask learners to do this without direction from you so that they talk to each other in order to aid recall. You teach the properties of an ideal gas and the assumptions involved.
4.1b	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	<ul style="list-style-type: none"> Learners work through virtual experiments with gases, changing temperature, volume using the university Oregon vlab site. (I) Provide worksheets about ideal gases and assumptions of kinetic theory. Intermolecular forces introduced by you at a simple level. Explain this is a concept that will be explained in more detail soon. <p> http://jersey.uoregon.edu/vlab/index.html These are a collection of interactive Java applets. </p>
4.1c	State and use the general gas equation $pV = nRT$ in calculations, including the determination of Mr.	<ul style="list-style-type: none"> You guide learners to discuss factors that make a difference to the pressure or volume of a gas. You introduce and explain the general gas equation. Learners practise using this equation in theoretical questions. (I) Learners use this equation in the evaluation and analysis of their own practical work to determine the molar mass of a gas e.g. Lainchbury Experiment 9.1 or Hutchings Experiment 17. Provide worksheets (with mark scheme) of more demanding examples. (I) Peer-marking of homework using mark scheme prepared by you. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
		http://www.rsc.org/learn-chemistry/resource/res00000401/the-determination-of-relative-atomic-mass
KC3 3.5a	Describe, interpret and 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.	<ul style="list-style-type: none"> You set the scene for the following sequence of lessons. <ul style="list-style-type: none"> Structures affect properties What do learners already know? (Q&A) What don't learners know yet? (Try to get out of them that intermolecular forces between gas particles are neither ionic, nor covalent, nor metallic). Learners look at some chemical and physical properties that are related to the type of bonding, such as Hill Practical 6, Structure, Bonding and Properties. Provide worksheets with twelve substances, 3 GI, 3GC, 3GM and 3SM, with properties. Properties include: <ul style="list-style-type: none"> Melting point Conductivity when solid Conductivity when liquid Conductivity in aq solution Solubility in water Solubility in hexane. Provide worksheets which lead learners to make generalisations e.g. 'Giant Ionic substances have high melting points'. Your choice of substances must make these generalisations obvious. <ul style="list-style-type: none"> Point out that there are exceptions but that's not what they're looking at yet. Learners answer prepared question sheet or from textbook. (I)
KC3 / KC2 3.3b	Understand, in simple terms, the concept of electronegativity and apply it to explain the properties of molecules such as bond polarity (see also LO 3.3.c), the dipole moments of molecules (LO 3.3.d) and the behaviour of oxides with water (LO 9.2.c).	<ul style="list-style-type: none"> You teach the concept of electronegativity. Learners research: <ul style="list-style-type: none"> Trends in electronegativity within Periodic Table including Linus Pauling's numerical values. Factors affecting electronegativity The effect of electronegativity on covalent bonds when there is: <ul style="list-style-type: none"> A large difference A small difference No difference. The consequence of bond polarity. Learners present findings to the class. <ul style="list-style-type: none"> Peer-marking of presentations using mark schemes prepared by you. (I) Learners summarise what they have learned. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC4 / KC5 3.3d	Describe intermolecular forces (van der Waals' forces), based on permanent and induced dipoles, as in, for example, $\text{CHCl}_3(\text{l})$; $\text{Br}_2(\text{l})$ and the liquid Group 18 elements.	<ul style="list-style-type: none"> You define intermolecular forces. Introduce the term van der Waals' forces as an umbrella term for all intermolecular forces. You describe forces based on permanent dipoles. Use Q&A to refer to work on electronegativity especially student research and presentation. Provide worksheets on polar bonds, absence of polar bonds, and the effect of both of these on: <ul style="list-style-type: none"> Melting point, Boiling point Solubility in water Solubility in hexane. (I) Provide worksheets (with mark scheme) for learners to practise this, extending understanding to include symmetrical molecules with polar bonds but no overall dipole. (I) You introduce the problem – substances like O_2 and CH_4 with non-polar molecules can be liquefied. Learners brainstorm what the forces might be and present ideas to the class. Criticism of ideas by other learners. Teach about forces based on temporary (instantaneous) dipoles, learners summarise this in diagrammatic form. (I) Learners research the factors that affect the strength of forces based on temporary dipoles. To include: <ul style="list-style-type: none"> size of electron charge cloud shape of molecule. Provide worksheets giving data on the boiling points of the hydrides of Groups 14, 15, 16, 17. Learners plot this data to produce a single graph and use the material learned on van der Waals' forces to explain: <ul style="list-style-type: none"> why the values rise for Group 14 why the values for Group 14 are below the values for Groups 15, 16, and 17 why NH_3, H_2O and HF appear anomalous. (I) <p>Note: In this course van der Waals' forces is used as an umbrella term for all intermolecular forces.</p>
KC4 / KC5 3.3a	Describe hydrogen bonding, using ammonia and water as simple examples of molecules containing N–H and O–H groups.	<ul style="list-style-type: none"> You explain H-bonds in simple terms giving reference to importance of H, N and O. Refer to work on electronegativity and forces based on permanent dipoles. <ul style="list-style-type: none"> Bend a stream of water coming out of a tap with an electrostatically charged (plastic) rod / ruler Video clip of an insect walking on water Ice floating on water Learners try to float a needle on water. Provide worksheets on how hydrogen bonds are formed and how to draw them in molecules to include: <ul style="list-style-type: none"> partial charges lone pair involvement role of H, N and O

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
		<ul style="list-style-type: none"> includes reference to HF. (I)
KC4 / KC5 3.5b	Deduce the type of bonding present from given information.	<ul style="list-style-type: none"> This is linked to LO 3.5.a and LOs 9.2.g, 9.3.b, 10.1.d and 11.1.b. Each learner researches two substances and prepares information about the properties of the two substances (such as (relative) boiling point, conductivity, solubility etc.) for homework. (I) Examples of pairs of substances: <ul style="list-style-type: none"> SiO_2 and Al NaCl and HCl H_2O and CH_4 $\text{C}_{10}\text{H}_{22}$ and CH_4 SiO_2 and CO_2 Then each learner presents this information to the class without revealing the identity of the substances. Peers must <ul style="list-style-type: none"> deduce the types of structure and bonding deduce, if the structures are both simple molecular, the van der Waals' forces present relate these deductions to the properties (I)
KC4 / KC5 4.3d	Suggest from quoted physical data the type of structure and bonding present in a substance.	<ul style="list-style-type: none"> This is linked to LO 3.5.b Learners work in pairs to prepare and then present to the class an explanation of how data about pairs of substances can show the type of structure and bonding present in each of them. Examples of pairs of substances: <ul style="list-style-type: none"> graphite and diamond MgO and Mg diamond and buckminsterfullerene. Peers mark presentations using mark schemes prepared by you. (I)
KC4 / KC5 4.3c	Outline the importance of hydrogen bonding to the physical properties of substances, including ice and water (for example, boiling and melting points, viscosity and surface tension).	<ul style="list-style-type: none"> This is linked to LO 3.5.a. Learners' practical work investigating: <ul style="list-style-type: none"> the viscosity of liquids, e.g. Lainchbury Experiment 3.4 the effect of hydrogen bonding on liquid flow the variation of boiling point with composition of a mixture of two liquids such as ethanol and cyclohexane, or propan-1-ol and propan-2-ol (or trichloromethane and methylethanoate as a demonstration) e.g. Lainchbury Experiment 3.5 Variation of boiling point with composition of mixture. Provide worksheets on H-bonding. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
		<ul style="list-style-type: none"> • Peer-marking of worksheets using mark schemes prepared by you. • Learners answer questions about the effects of hydrogen bonding, for example prepared by you or in textbooks. (I)
KC5 4.3b	Discuss the finite nature of materials as a resource and the importance of recycling processes.	<ul style="list-style-type: none"> • Learners research and bring to the lesson information that they have found out about recycling opportunities within, for example, 1km of their home. (I) • Discuss how well recycling occurs in their location and what motivates or puts people off recycling. • As a revision exercise learners discuss this, along with the biodegradability of polymers (LO 21.4 a & b) in terms of the key concept of <i>energy changes</i>.
Past and specimen papers		
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3: Controlling reactions 1

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC5 5.1a	Explain that chemical reactions are accompanied by energy changes, principally in the form of heat energy; the energy changes can be exothermic (ΔH is negative) or endothermic (ΔH is positive).	<ul style="list-style-type: none"> Learners recap IGCSE knowledge with some simple practical work of measuring temperature changes of reactions such as <ul style="list-style-type: none"> $\text{NaOH} + \text{HCl}$, $\text{NaHCO}_3 + \text{citric acid}$, $\text{NH}_4\text{Cl} + \text{water}$ $\text{Mg} + \text{H}_2\text{SO}_4$. Lainchbury Experiments 2.1 and 2.2 and Practical Booklet 4. You explain the meanings of exothermic and endothermic.
KC5 / KC4 3.5c	Show understanding of chemical reactions in terms of energy transfers associated with the breaking and making of chemical bonds.	<ul style="list-style-type: none"> Do as a revision exercise, since it crosses a number of topics: <ul style="list-style-type: none"> bonding energy transfer activation energy the key concept of <i>chemical bonds</i> the key concept of <i>energy changes</i>, would be a good way for learners to discuss these ideas. Learners research then present to the class: <ul style="list-style-type: none"> the reasons behind the trend in volatility of the halogens the variation in solubility of Group 2 hydroxides and sulfates.
KC3 / KC4 / KC5 3.3c	Explain the terms <i>bond energy</i> , <i>bond length</i> and <i>bond polarity</i> and use them to compare the reactivities of covalent bonds (see also LO 5.1.b(ii)).	<ul style="list-style-type: none"> You teach the meaning of bond energy, bond length, and bond polarity. Learners research and discuss how the trend in reactivity in halogenoalkanes is determined by the carbon-halogen bond. Learners' practical work, e.g. Lainchbury experiment 3.3 Testing liquids for polarity. Planning an investigation such as Hill S4 Investigating the effect of a charged rod on liquid jets.
KC5 5.1b	Explain and use the terms: (i) enthalpy change of reaction and	<ul style="list-style-type: none"> Learners in paired activity learn all the definitions in this LO <ul style="list-style-type: none"> recite definition to partner give an equation to go with the definition partner assesses and feeds back

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	<p>standard conditions, with particular reference to: formation, combustion, hydration, solution, neutralisation, atomisation</p> <p>(ii) bond energy (ΔH positive, i.e. bond breaking).</p>	<ul style="list-style-type: none"> ○ partners switch roles. ● Provide worksheets with 18 equations, learners must recognise 3 enthalpy changes of formation, 3 enthalpy changes of combustion, etc. ● Learners produce their own version of the worksheet with mark scheme. (I) ● Learners swap worksheets in pairs, complete their partner's sheet, then swap again and mark.
KC5 5.1c	<p>Calculate enthalpy changes from appropriate experimental results, including the use of the relationship enthalpy change, $\Delta H = -mc\Delta T$.</p>	<ul style="list-style-type: none"> ● Learners' practical work, <ul style="list-style-type: none"> ○ burning various alcohols <ul style="list-style-type: none"> ■ methanol ■ ethanol ■ propanol and butanol <p>to heat water and then using $\Delta H = mc\Delta T$ to determine a value for the enthalpy change of combustion for each reaction. See Lainchbury experiments 2.4, 2.5 & 2.6 for other variations of using this experimental method.</p> ● Provide worksheets practising calculations involving this method. (I) ● Peer-marking of worksheets using mark schemes prepared by you.
KC5 5.2a	<p>Apply Hess' Law to construct simple energy cycles, and carry out calculations involving such cycles and relevant energy terms, with particular reference to:</p> <p>(i) determining enthalpy changes that cannot be found by direct experiment, e.g. an enthalpy change of</p>	<ul style="list-style-type: none"> ● Learners' practical work <ul style="list-style-type: none"> ○ the enthalpy change of the formation of hydrated magnesium sulfate from magnesium sulfate dissolving in water, (Lainchbury Experiment 2.3) ○ the same experiment for sodium thiosulfate ○ the same experiment for copper sulfate. ● You then show learners how to 'draw' Hess' Law diagrams / cycles to interpret practicals. ● Learners practice calculations themselves using prepared worksheets with examples. Peer tutoring and peer assessment here, since learners are likely to need to complete quite a lot of questions to practise. ● Provide worksheets to introduce Hess' Law calculations that use bond energies. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	formation from enthalpy changes of combustion (ii) average bond energies	
KC5 15.3a	Describe and explain how the combustion reactions of alkanes led to their use as fuels in industry, in the home and in transport.	<ul style="list-style-type: none"> Learners write equations for the complete combustion of various alkanes. Learners use average bond energies to calculate ΔH°_c for these reactions. You lead discussion on the amount of energy released per g as a factor in choosing fuels. Learners research which alkanes have and are used as fuels and the contexts in which they are used. (I)
KC5 15.3b	Recognise the environmental consequences of: (i) carbon monoxide, oxides of nitrogen and unburnt hydrocarbons arising from the internal combustion engine and of their catalytic removal (ii) gases that contribute to the enhanced greenhouse effect.	<ul style="list-style-type: none"> Learners research the chemistry of the internal combustion engine to include <ul style="list-style-type: none"> environmental discussions fuel additives e.g. tetraethyl lead current legislation in the home country. Learners deliver presentations. Peer-marking of presentations using mark schemes prepared by you.
13.2a	Describe the formation of atmospheric sulfur dioxide from the combustion of sulfur-contaminated fossil fuels.	<ul style="list-style-type: none"> You demonstrate the burning of sulfur in a gas jar full of oxygen, then add a small amount of water and (universal) indicator to the sulfur dioxide formed.
13.2b	State the role of sulfur dioxide in the formation of acid rain and describe the	<ul style="list-style-type: none"> Show photographs of buildings in c.1900 and now as evidence of corrosion. Learners say everything they know about acid rain in 30 seconds to the rest of the class. Peers criticise each one on the basis of:

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	main environmental consequences of acid rain.	<ul style="list-style-type: none"> ○ how scientific they were in the language they used ○ what chemists might say differently, ● coverage of other consequences of acid rain.
15.3c	Outline the use of infra-red spectroscopy in monitoring air pollution (see also LO 22.2).	<ul style="list-style-type: none"> ● You teach which bonds absorb infra-red radiation and why. Link to global warming. ● Extension activity: You ask learners which bonds in which molecules in air can be detected using IR spectroscopy. For example the C=O bond in CO₂. ● Learners decide which air constituents contribute to global warming and which are increasing in amount.
KC3 6.1a	Calculate oxidation numbers of elements in compounds and ions.	<ul style="list-style-type: none"> ● Learners to sort a number of statements into those associated with oxidation and those associated with reduction using their knowledge from IGCSE. <ul style="list-style-type: none"> ○ Statements to include <ul style="list-style-type: none"> ▪ losing and gaining electrons, ▪ losing and gaining oxygen, ▪ increase and decrease in oxidation number. (I) ● Learners then create a checklist for determining the oxidation number of elements in compounds. ● Learners then create a checklist for using oxidation number changes to balance equations. ● Learners practise both of these skills in questions. (I) ● Learners' practical work, for example in the titration of potassium manganate(VII) or potassium chromate (VI) with iron(II) ions, or of sodium thiosulfate with iodine.
KC3 / KC4 6.1b	Describe and explain redox processes in terms of electron transfer and changes in oxidation number.	<ul style="list-style-type: none"> ● Provide worksheets of balanced chemical equations, all for redox processes, learners must use oxidation numbers to identify the species that are oxidised and the species that are reduced. ● You teach how to produce half-equations. ● Learners produce half-equations for species oxidised and species reduced, confirming: <ul style="list-style-type: none"> ○ oxidation is loss of electrons ● reduction is gain of electrons.
KC3 / KC4 6.1c	Use changes in oxidation numbers to help balance chemical equations.	<ul style="list-style-type: none"> ● Provide worksheets of balanced chemical equations, all for redox processes, learners must use oxidation numbers to balance the chemical equations. ● Learners are each given a certain numbers of equations to present to the class and to explain their balancing method. (I)
8.1a	Explain and use the term <i>rate of reaction</i> .	<ul style="list-style-type: none"> ● Learners each talk for 30 seconds about rates of reaction from their IGCSE / O Level course. (I) ● Other learners mark each other using mark schemes prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
8.1b	Explain qualitatively, in terms of collisions, the effect of concentration changes on the rate of a reaction.	<ul style="list-style-type: none"> Learners role-play to simulate collision theory. Create a space to be the reaction vessel and more or less learners walk about in it blindfolded. Whenever they touch each other (collide) they shout 'reaction'. When there are more of them (particles) in the same space they will 'hear' reactions more often. Learners' practical – 'thiosulfate cross' experiment.
5.2b	Construct and interpret a reaction pathway diagram, in terms of the enthalpy change of the reaction and of the activation energy.	<ul style="list-style-type: none"> This could be linked to LO 8.2.a You introduce using numerical values and drawing pathway diagrams for simple reactions such as hydrochloric acid and sodium hydroxide or the combustion of methane. Learners draw diagrams in pairs, <ul style="list-style-type: none"> suggesting reactions for each other using bond energies to work out the bonds broken and the bonds formed and therefore the ΔH of the reaction putting the numbers on the diagram.
KC5 8.3a	Explain and use the term <i>catalysis</i> .	<ul style="list-style-type: none"> Learners' practical (an extension of a previous practical.) to determine the activation energy of the reaction between $\text{S}_2\text{O}_8^{2-}$ and I^- ions (e.g. Lainchbury Experiment 9.7) This involves planning and then carrying out this investigation and finding the activation energy for this reaction when catalysed.
KC5 8.3b	Explain that catalysts can be homogenous or heterogeneous.	<ul style="list-style-type: none"> Learners are put into three groups to research and create a presentation about catalysts. Different learners are given different LOs from 8.3 so that all of 8.3 is covered. The first learner/pair/group is given 8.3a and 8.3b (see below for 8.3c and 8.3d.).
KC5 8.3c	(i) explain that, in the presence of a catalyst, a reaction has a different mechanism, i.e. one of lower activation energy (ii) interpret this catalytic effect in terms of the Boltzmann distribution	<ul style="list-style-type: none"> Learners are put into three groups to research and create a presentation about catalysts. Different learners are given different LOs from 8.3 so that all of 8.3 is covered. The second learner/pair/group is given 8.3.c (i) and (ii).

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC5 8.3d	Describe enzymes as biological catalysts (proteins) which may have specificity.	<ul style="list-style-type: none"> Learners are put into three groups to research and create a presentation about catalysts. Different learners are given different LOs from 8.3 so that all of 8.3 is covered. The third learner/pair/group is given 8.3.d. Presentations are delivered to the class. Other learners mark each presentation using mark schemes prepared by you. It should be noted that when learner research and presentation is used the preparation of a mark scheme and a marking activity is essential to ensuring every learner gains the correct knowledge. Provide worksheets for homework covering all of 8.3.a-d. (I)
KC5 8.2a	Explain and use the term activation energy, including reference to the Boltzmann distribution.	<ul style="list-style-type: none"> You teach the Boltzmann distribution. Key points: <ul style="list-style-type: none"> The labelling of the axes The shape of the curve The shape of the curve at higher and lower temperatures A value for E_A and the identification of reacting molecules What happens to the number of reacting molecules at higher and lower temperatures A value for E_A in the presence of a catalyst and the identification of reacting molecules. Learners work in pairs. The task of learner 1 is to draw a Boltzmann distribution and use it to explain what happens to the rate of a reaction when: <ul style="list-style-type: none"> T increases T decreases a catalyst is added Learner 2 marks this using a mark scheme prepared by you. Learners 1 and 2 exchange roles. Provide worksheets consisting of as many relevant multiple choice questions (Paper 1) as you can find. (I)
KC5 8.2b	Explain qualitatively, in terms both of the Boltzmann distribution and of collision frequency, the effect of temperature change on the rate of a reaction.	<ul style="list-style-type: none"> Marking exercise using homework from 8.2a and mark scheme prepared by you. Learners must explain their reason for their choices. You use this as an opportunity to teach learners how to approach paper 1, ruling out certain answers and annotating the Q paper to help make decisions. You teach the effect of temperature change on collision frequency, but emphasise that the increase in the proportion of collisions with E_A is more important.
KC2 / KC5 7.1a	Explain, in terms of rates of the forward and	<ul style="list-style-type: none"> Demonstration – show a number of reactions, some of which are reversible, some not, and some in equilibrium and some not.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	reverse reactions, what is meant by a <i>reversible reaction</i> and <i>dynamic equilibrium</i> .	<ul style="list-style-type: none"> ○ heat and cool chocolate, ○ heat and cool an egg, ○ heat and cool zinc oxide to show the idea of reversibility. ○ $\text{CrO}_4^{2-}(\text{aq})$ and $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$, the reaction being reversed by $\text{H}^+(\text{aq})$ or $\text{OH}^-(\text{aq})$ ions ○ pink solution of cobalt chloride which you warm to turn blue and cool in ice to turn back to pink. <ul style="list-style-type: none"> ● Learners in pairs set up a dynamic equilibrium model using molecular models. Start with ten N_2 molecules and 30 H_2 molecules. One student has to create NH_3 molecules while the other has to return them to $\text{N}_2 + \text{H}_2$. If they do this at the same time an equilibrium will be created. ● Learners write up what they have learned from paired activity. To include: <ul style="list-style-type: none"> ○ dynamic nature of equilibrium ○ concept of equilibrium position. (I) <p> http://www.rsc.org/learn-chemistry/resource/res00000117/afl-equilibrium-reactions http://www.rsc.org/learn-chemistry/resource/res00000001/cobalt-equilibrium </p>
KC5 7.1b	State Le Chatelier's principle and apply it to deduce qualitatively (from appropriate information) the effects of changes in temperature, concentration or pressure on a system at equilibrium.	<ul style="list-style-type: none"> ● You write Le Chatelier's principle on the board. ● Learners in pairs re-write it so that either a 12-year-old or one of their peers who is not studying any science A Levels, could understand it. ● You teach how Le Chatelier's principle is applied. ● Learners in pairs apply this principle to a number of equilibria when a particular change is made to that system. (If possible each pair should have a different situation). ● Learners then share their answers with the rest of the class in turn. ● You relate the changing factors (e.g. T, P, conc.) to their knowledge of how these factors change the rate of reaction. ● Learners' practical work such as Lainchbury Experiment 6.1 The effect of concentration changes on equilibria where solutions of FeCl_3 and $\text{KSCN}(\text{aq})$ are mixed to form an equilibrium. ● Provide worksheets - what is the effect of a change in P or T or concentration on the following equilibria? (I)
KC5 7.1c	State whether changes in temperature, concentration or pressure or the presence of a catalyst affect the value of the equilibrium constant for a reaction.	<ul style="list-style-type: none"> ● You explain the idea of an equilibrium constant (see LO 7.1.d). ● Learners then research the effects of temperature, pressure, concentration and catalysts on equilibrium constants. (I) ● Learners present their findings. ● Other learners use mark scheme prepared by you to peer-assess. <p> http://www.rsc.org/learn-chemistry/resource/res00000001/cobalt-equilibrium </p>

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC2 7.1d	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).	<ul style="list-style-type: none"> Learners' practical work to determine an equilibrium constant, e.g. the equilibrium of ethyl ethanoate and water with ethanol and ethanoic acid, e.g. Lainchbury Experiment 6.2 or Hill Practical 14 (NB you probably need to set up and leave this for at least 48 hours for the system to reach equilibrium.). Learners write up ethyl ethanoate practical, paying particular attention to how the ethyl ethanoate, water and ethanol concentrations at equilibrium are calculated. (I) Learners practise writing K_c and K_p expressions for a number of equilibria. <p>http://www.rsc.org/learn-chemistry/resource/res00000537/measuring-an-equilibrium-constant</p>
7.1e	Calculate the values of equilibrium constants in terms of concentrations or partial pressures from appropriate data.	<p>This lesson should be delivered equally in the context of K_c and K_p.</p> <ul style="list-style-type: none"> Provide worksheets requiring writing K_c expressions and calculating a value from supplied data. (I) Start with the equilibrium they have investigated practically in LO 7.1.d. (I) Learners work in pairs to carry out peer assessment of these calculations. Provide worksheet of more examples for homework. (I)
7.1f	Calculate the quantities present at equilibrium, given appropriate data (such calculations will <i>not</i> require the solving of quadratic equations).	<p>This lesson should be delivered equally in the context of K_c and K_p.</p> <ul style="list-style-type: none"> Provide worksheets with equations for reversible reactions, and data giving K_c and all other concentrations except one. Learners write the expression for K_c then rearrange it to find the value of the missing concentration term in the expression. (I) You explain how to use the stoichiometry of a balanced chemical equation to solve a problem with these steps: <ul style="list-style-type: none"> The balanced chemical equation is supplied Starting concentrations are given The equilibrium concentration of one reactant or product is given The equilibrium concentrations of all other reactants and products are then calculated using the stoichiometry. The equilibrium constant can then be calculated. Provide worksheets to practise this method. (I)
7.1g	Describe and explain the conditions used in the Haber process and the Contact process, as examples of the importance of an	<ul style="list-style-type: none"> Learners research these two industrial processes and produce a report about why the particular conditions of temperature, pressure and catalyst are chosen in practice. (I) Reports are evaluated by other learners using mark schemes prepared by you. Hold an 'ask the expert' session <ul style="list-style-type: none"> one learner role-plays the manager for a plant producing ammonia or sulfuric acid, the rest of the learners ask them questions such as

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	understanding of chemical equilibrium in the chemical industry.	<ul style="list-style-type: none"> ▪ Why don't you use a higher temperature to have a faster rate of reaction? ▪ If you need to reduce your CO₂ emissions from burning fuel to have a high temperature, why not use lower temperature? ▪ If it costs so much to produce high pressure, why not use low pressure? ○ Learners switch roles.
KC5 7.2a	Show understanding of, and use, the Brønsted-Lowry theory of acids and bases, including the use of the acid-I base-I, acid-II base-II concept.	<ul style="list-style-type: none"> • Learners to draw 'dot and cross' diagrams for H₃O⁺, OH⁻ and NH₄⁺. • Learners talk in pairs and list everything they know about acids and bases. <ul style="list-style-type: none"> ○ Have some familiar acids, bases and indicators as prompts, link this with an acid-base titration practise or with experiments with acids and bases such as Hill Practical 10, Acids, Bases and Indicators, experiments 1 & 2. • You explain Brønsted-Lowry theory of acids and bases. • Learners then practise using new definitions <ul style="list-style-type: none"> ○ to identify acids and bases in practical work ○ to identify conjugate pairs in practical work. ○ to complete prepared worksheet for homework. (I)
KC3 7.2b	Explain qualitatively the differences in behaviour between strong and weak acids and bases and the pH values of their aqueous solutions in terms of the extent of dissociation.	<ul style="list-style-type: none"> • Display of acids and bases with Universal indicator in them <ul style="list-style-type: none"> ○ HCl (aq) ○ vinegar ○ Ca(OH)₂ (aq) ○ NaOH (aq) ○ NH₃ (aq) • Discuss the terms weak and strong (which should be familiar from IGCSE / O Level) • Extend understanding into equations showing acids and bases in an equilibrium reaction (called dissociation.) • Concept of strong and weak acids explained in terms of extent of dissociation and equilibrium position. • Learners practise writing equilibria equations for common acids and bases. • Learners identify conjugate acid/base pairs in their examples. (I)
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support (F)		

4: Organic chemistry 1

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC1 14.1a	<p>Interpret and use the general, structural, displayed and skeletal formulae of the following classes of compound:</p> <ul style="list-style-type: none"> (i) alkanes and alkenes (ii) halogenoalkanes (iii) alcohols (including primary, secondary and tertiary) (iv) aldehydes and ketones (v) carboxylic acids and esters (vi) amines (primary only), nitriles and amides. <p>(Candidates will be expected to recognise the shape of the benzene ring when it is present in organic compounds. Knowledge of benzene or its compounds is <i>not</i> required for AS Level.)</p>	<ul style="list-style-type: none"> • Learners work in pairs to make molecular models of <ul style="list-style-type: none"> ○ alkanes ○ alkenes ○ halogenoalkanes ○ primary, secondary and tertiary alcohols ○ aldehydes ○ ketones ○ carboxylic acids ○ esters ○ amines ○ nitriles • Learners use models to practise drawing the general, structural, displayed and skeletal formulae for each molecule.
KC1 14.1b	<p>Understand and use systematic nomenclature of simple aliphatic organic molecules with functional groups detailed in 14.1.a, up to six carbon atoms</p>	<ul style="list-style-type: none"> • You teach how the organic naming system works. • Learners use the models they made and their 2-D drawings to practise naming molecules. • Learners work in pairs to create a checklist of how to do this. • You extend this to more difficult molecules on the board and give learners a mini whiteboard each that they write the name onto and show you when they have worked it out. (I) • Provide worksheets for learners to practice examples. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	(six plus six for esters and amides, straight chains only).	<ul style="list-style-type: none"> Peer-marking of worksheets using mark schemes prepared by you.
KC1 14.1d	Deduce the possible isomers for an organic molecule of known molecular formula.	<ul style="list-style-type: none"> You teach the meaning of the term <i>isomer</i> and give examples. Learners work in pairs, <ul style="list-style-type: none"> Learner 1 draws a structure (using whichever type of formula they choose) Learner 2 works out the molecular formula of it and draws the structure of an isomer Learner 1 draws another isomer Continue until no more isomers. Learners must be vigilant for formulae that look different but are not. Swap roles.
KC1 14.1e	Deduce the molecular formula of a compound, given its structural, displayed or skeletal formula.	<ul style="list-style-type: none"> Provide worksheets giving structural and displayed formulae of 20 different compounds. Learners must find the molecular formula of each compound and put the 20 into 5 groups of 4 isomers in each group. Learners must deduce a fifth isomer to go in each group. (I) Peer-marking of worksheets using mark schemes prepared by you.
KC1 14.2a	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, condensation	<ul style="list-style-type: none"> Learners research one of these terms each and give a presentation. (I) Learners mark presentations using mark schemes prepared by you and give feedback to presenter. You will use the first contexts in which these terms subsequently occur to revisit this learning. Occasional revision activity where learners in pairs have to define 2 or 3 of these terms Learners to begin to make a table or mind map for each term. They add to the table each reaction that is associated with that term. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	(vi) oxidation and reduction (in equations for organic redox reactions, the symbols [O] and [H] are acceptable for oxidising and reducing agents).	
KC3 15.1a	Understand the general unreactivity of alkanes, including towards polar reagents.	<ul style="list-style-type: none"> Each learner says everything they can remember from IGCSE / O Level about alkanes in 30 seconds. (I) You show learners examples of alkanes such as methane, pentane, hexane. You show these alkanes' unreactivity with water by passing the gas into water or shaking the liquids together.
KC2 / KC3 15.1b	Describe the chemistry of alkanes as exemplified by the following reactions of ethane: (i) combustion (ii) substitution by chlorine and by bromine.	<ul style="list-style-type: none"> Learners investigate these reactions practically, e.g. Lainchbury Experiment 5.1 Chemical properties of alkanes or Hill Practical 25 Alkanes. Learners write up practical work, writing balanced chemical equations for all reactions. (I) <p>www.s-cool.co.uk</p>
KC1 / KC4 15.1c	Describe the mechanism of free-radical substitution at methyl groups with particular reference to the initiation, propagation and termination reactions.	<ul style="list-style-type: none"> You give learners sets of card with an equation for either initiation, propagation or termination on each one. Learners sort the cards into a correct reaction order. Differentiate by having sets of cards that have no spares, and having sets that include additional unnecessary steps.
KC4 / KC5 15.1d	Explain the use of crude oil as a source of both aliphatic and aromatic hydrocarbons.	<ul style="list-style-type: none"> You show a simple demonstration of distillation of 'imitation' crude oil with 3 or 4 components in it with boiling points ranging from approximately 50°C to approximately 350°C. Provide worksheets to include <ul style="list-style-type: none"> how fractional distillation works the fractions produced (they will have some knowledge of this from IGCSE). (I) <p>http://www.rsc.org/learn-chemistry/resource/res00000754/the-fractional-distillation-of-crude-oil</p>

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC4 / KC5 15.1e	Suggest how cracking can be used to obtain more useful alkanes and alkenes of lower M_r from larger hydrocarbon molecules.	<ul style="list-style-type: none"> You demonstrate cracking of paraffin, Hill Practical 25. You teach the economic relevance of cracking. Learners then use models of long chain molecules (larger than C_{10}) to demonstrate cracking into two or more fragments. <p>http://www.rsc.org/learn-chemistry/resource/res00000681/cracking-hydrocarbons</p>
KC2 / KC3 15.2a	Describe the chemistry of alkenes as exemplified, where relevant, by the following reactions of ethene and propene (including the Markovnikov addition of asymmetric electrophiles to alkenes using propene as an example): (i) addition of hydrogen, steam, hydrogen halides and halogens (ii) oxidation by cold, dilute, acidified manganate(VII) ions to form the diol (iii) oxidation by hot, concentrated, acidified manganate(VII) ions leading to the rupture of the carbon–carbon double bond in order to determine the position of alkene linkages in larger molecules	<ul style="list-style-type: none"> Learners could investigate as many of these reactions as possible practically, e.g. Hill Practical 26 or Lainchbury Experiment 5.2. You teach those that can't be done practically. You emphasise the significance of a functional group, e.g. it doesn't matter what the rest of the molecule is when you're adding $Br_2(l)$ to an alkene, the same thing happens. You teach Markovnikov addition and explain that the rest of the molecule can have some influence when you're adding HBr to an alkene. Learners write up practical work, writing balanced chemical equations for all reactions. (I) Provide worksheets so learners have to apply all of the reactions they have studied to other alkenes. (I) Peer-marking of worksheets with feedback, using mark schemes prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	(iv) polymerisation (see also Section 21).	
KC2 / KC3 / KC4 15.2b	Describe the mechanism of electrophilic addition in alkenes, using bromine/ethene and hydrogen bromide/propene as examples.	<ul style="list-style-type: none"> You teach the mechanism of electrophilic addition. Learners demonstrate this mechanism to each other using molecular models to: <ul style="list-style-type: none"> make a model of each alkene and each reagent indicate the partial charge on the Br₂ and on the HBr molecule by putting coloured stickers or paper on the one with the positive partial charge. break and make bonds in the right order to represent the reaction. Learners then practise drawing out the mechanism using curly arrows. (I) Peer-marking of drawings using mark scheme prepared by you. Provide worksheets of more examples of electrophilic addition. (I)
KC2 / KC3 / KC4 / KC5 15.2c	Describe and explain the inductive effects of alkyl groups on the stability of cations formed during electrophilic addition.	<ul style="list-style-type: none"> You teach the term inductive effect and point out its significance to electrophilic addition and Markovnikov addition in particular. You draw diagrams of the electron clouds around various structures such as CH₃CH₂⁺, (CH₃)₂CH⁺ and (CH₃)₃C⁺ and use them to discuss <ul style="list-style-type: none"> the inductive effects the difference that the number of methyl groups makes to the stability of the carbocation.
KC4 15.2d	Describe the characteristics of addition polymerisation as exemplified by poly(ethene) and PVC.	<ul style="list-style-type: none"> Learners make models of ethene, then make one big chain of polythene Learners make models of chloroethene, then make one big chain of PVC. Provide worksheets – thinking through the bond breaking and making that occurs in this process, focusing particularly on σ and π bonds. (I) <p>http://www.rsc.org/learn-chemistry/resource/res00000028/polythene</p>
KC4 15.2e	Deduce the repeat unit of an addition polymer obtained from a given monomer.	<ul style="list-style-type: none"> Each learner has a different monomer unit Mini-presentation at the board – this monomer produces this polymer. Correct showing of repeat unit is important. (I) Provide worksheets practising using monomer to deduce structure of polymer and to show repeat unit correctly. (I)
KC4 15.2f	Identify the monomer(s) present in a given section	<ul style="list-style-type: none"> Provide worksheets in which they must deduce the monomer from: <ul style="list-style-type: none"> section of a polymer chain more than 1 repeat unit long

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	of an addition polymer molecule.	<ul style="list-style-type: none"> ○ conventional showing of repeat unit. (I) ● Extend to include polymers with more than one type of monomer. (I)
KC5 15.2g	Recognise the difficulty of the disposal of poly(alkene)s, i.e. nonbiodegradability and harmful combustion products.	<ul style="list-style-type: none"> ● Learners research into means of disposing of waste polymer. To include: <ul style="list-style-type: none"> ○ landfill (with biodegradability issues) ○ combustion (with harmful product issues) ○ recycling and reusing. ● Learners give presentations which are peer-marked using mark schemes prepared by you.
KC1 22.2a	Analyse an infra-red spectrum of a simple molecule to identify functional groups (see the <i>Data Booklet</i> for functional groups required in the syllabus).	<ul style="list-style-type: none"> ● You take the learners to see an infra-red spectrometer in action and obtain some traces of some simple organic molecules. This visit might be combined with mass spectrometer and GLC. ● Learners use the <i>Data Booklet</i> to find predicted absorptions and compare with the traces. ● Learners then practise interpreting the traces of unknowns and state what functional group(s) are present. (I) ● Practise questions, either produced by you or from a textbook. (I) <p>http://www.rsc.org/learn-chemistry/resource/res00000283/spectroscopy-in-a-suitcase-ir-student-resources</p>
KC1 14.4a	Describe structural isomerism and its division into chain, positional and functional group isomerism.	<ul style="list-style-type: none"> ● Use the molecular models that learners made in LO 14.1.a & 14.1.c as the start of this topic. ● Learners find or make some isomeric structures ● Learners discuss the basis of difference between these isomers <ul style="list-style-type: none"> ○ Learners draw and describe those isomers that are chain isomers i.e. the difference lies in the carbon skeleton, e.g. butane and methylpropane. ○ Learners draw and describe those isomers that are position isomers i.e. the carbon skeleton is unchanged but the difference lies in the position of important groups, e.g. pentan-2-ol and pentan-3-ol ○ Learners draw and describe those isomers that are functional group isomers i.e. the the carbon skeleton is unchanged but the difference lies in the functional groups formed by other atoms, e.g. propanone and propanal ○ Learners draw and describe those isomers that show a mixture of types of isomerism, e.g. butan-1-ol and methylpropan-2-ol. ● Provide worksheets with 20 structures consisting of 10 pairs of isomers. <ul style="list-style-type: none"> ○ Learners identify isomers ○ Learners identify type of isomerism in each pair. (I) ● Peer-marking activity using mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC1 14.4b	Describe stereoisomerism and its division into geometrical (cis-trans) and optical isomerism (use of E, Z nomenclature is acceptable but is <i>not</i> required).	<ul style="list-style-type: none"> Learners could make molecular models of but-2-ene and compare the structures they have made. You teach the vocabulary <ul style="list-style-type: none"> stereoisomerism geometric cis/trans restricted rotation Learners could make molecular models of butan-2-ol and compare the structures they have made. You teach the vocabulary <ul style="list-style-type: none"> stereoisomerism optical non-superimposable mirror image You teach the 3-D drawing conventions. Provide worksheets with 20 compounds consisting of 10 pairs of isomers, 5 geometric and 5 optical. Learners copy pairs, name the cis and trans, draw the optical isomers as mirror images. (I) Peer-marking of worksheet using mark scheme prepared by you.
KC1 14.4c	Describe cis-trans isomerism in alkenes, and explain its origin in terms of restricted rotation due to the presence of π bonds.	<ul style="list-style-type: none"> Learners compare but-2-ene model with a butane model to see the restricted rotation. You show a diagram on the board and use balloon p orbital sideways overlap of the electron clouds of the π bond and then lead a discussion linking these two ideas together. Learners then complete a worksheet prepared by you where they practise drawing and labelling cis-trans isomers and describe the conditions necessary for geometric isomers to arise. (I)
KC1 14.4d	Explain what is meant by a chiral centre and that such a centre normally gives rise to optical isomerism (Candidates should appreciate that compounds can contain more than one chiral centre, but knowledge of meso compounds, or nomenclature such as	<ul style="list-style-type: none"> Learners construct models of 1,2-dibromopropane and 2-hydroxypropanoic (lactic) acid and compare the carbon atoms within each molecule. You ask them to find the carbon atom that has four different groups attached in each molecule. Learners practise representing these 3-D structures on paper in 2-D with wedges and hatches for the bonds. (I) <p>http://www.rsc.org/learn-chemistry/resource/res00001261/khan-academy-stereochemistry</p>

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	<i>diastereoisomers</i> is not required.).	
KC1 14.4e	Identify chiral centres and cis-trans isomerism in a molecule of given structural formula.	<ul style="list-style-type: none"> Learners draw and bring to the lesson <ul style="list-style-type: none"> a diagram of an organic structure that contains at least one chiral centre. (I) a diagram of an organic structure that has a geometric isomer. Each learner's structures drawn or projected on the board and other learners find the chiral centre(s) and draw the other geometric isomer as appropriate. Extend this to practise more challenging questions, either provided by you or in textbook. (I)
KC2 / KC3 16.1a	Recall the chemistry of halogenoalkanes as exemplified by: (i) the following nucleophilic substitution reactions of bromoethane: hydrolysis, formation of nitriles, formation of primary amines by reaction with ammonia (ii) the elimination of hydrogen bromide from 2-bromopropane.	<ul style="list-style-type: none"> Learners investigate all of these reactions practically e.g. Hill Practical 28 or Lainchbury Experiment 5.3 & 5.4. Learners create a mind map or table of these reactions, including the equations and conditions for each one. (I)
KC2 16.1b	Describe the S_N1 and S_N2 mechanisms of nucleophilic substitution in halogenoalkanes including the inductive effects of alkyl groups (see LO 15.2.c).	<ul style="list-style-type: none"> Learners investigate the kinetics of the hydrolysis of bromobutane (either in the context of unit 8 or unit 16), either: <ul style="list-style-type: none"> practically, sampling and titrating periodically theoretically with supplied data giving concentrations and initial rates. Learners see that the rate of reaction depends on the concentration of both the hydroxide ions and the primary halogenoalkane. Learners compare this to a tertiary halogenoalkane (practically or with supplied data). You explain the terms S_N1 and S_N2 and take learners through the mechanisms with curly arrows etc. Provide worksheets leading learners through drawing these mechanisms. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
		<ul style="list-style-type: none"> Peer marking of worksheet using mark scheme prepared by you. <p>http://www.rsc.org/learn-chemistry/resource/res00000115/afl-nucleophilic-substitution-reaction-mechanisms</p>
KC3 / KC4 16.1c	Recall that primary halogenoalkanes tend to react via the S _N 2 mechanism; tertiary halogenoalkanes via the S _N 1 mechanism and secondary halogenoalkanes by a mixture of the two, depending on structure.	<ul style="list-style-type: none"> You explain <ul style="list-style-type: none"> primary halogenoalkanes react mainly by S_N2 mechanism tertiary halogenoalkanes react mainly by S_N1 mechanism. Learners must suggest reasons why. <ul style="list-style-type: none"> You make up prompt cards, some say 'inductive effect', some say 'consider how the inductive effect would stabilise an intermediate cation if the mechanism is S_N1'. You give a prompt card to a pair/group as needed. Learners present decisions to the group. Provide worksheets with equations, learners must <ul style="list-style-type: none"> predict a mechanism, S_N1 or S_N2 justify their choice, explaining why it's S_N1 or S_N2 describe the mechanisms with curly arrows etc. (I)
KC2 / KC5 16.2a	Interpret the different reactivities of halogenoalkanes (with particular reference to hydrolysis and to the relative strengths of the C-Hal bonds).	<ul style="list-style-type: none"> Learners talk in pairs about the test for halogen ions with silver ions from LO 11.3.a (i). Learners investigate practically the speed that the silver halide precipitates appear when halogenoalkanes are put into ethanolic aqueous silver nitrate. Learners use the Data Booklet to find bond energies of the carbon-halogen bond to explain their observations. <p>http://www.rsc.org/learn-chemistry/resource/res00000454/making-a-photographic-print</p>
KC4 16.2b	Explain the uses of fluoroalkanes and fluorohalogenoalkanes in terms of their relative chemical inertness.	<ul style="list-style-type: none"> Learners research this. (I) Learners' presentations to class, max 200 words. Peer-marking of presentations using mark scheme prepared by you.
KC4 16.2c	Recognise the concern about the effect of chlorofluoroalkanes on the ozone layer.	<ul style="list-style-type: none"> Combine with LO 16.2.b. Learners research this. (I) Learners' presentations to class, max 200 words. Peer-marking of presentations using mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC2 17.1a	Recall the chemistry of alcohols, exemplified by ethanol, in the following reactions: (i) combustion (ii) substitution to give halogenoalkanes (iii) reaction with sodium (iv) oxidation to carbonyl compounds and carboxylic acids (v) dehydration to alkenes (vi) formation of esters by esterification with carboxylic acids.	<ul style="list-style-type: none"> Learners investigate these reactions practically e.g. Hill Practical 30 Alcohols or Lainchbury Experiment 8.1. Learners create a mind map or table showing these reactions and also how they relate to other classes of compound they have already learned about (e.g. the dehydration to alkenes reaction). Learners write up the practical with equations for all reactions. (I) <p> http://www.rsc.org/learn-chemistry/resource/res00000463/properties-of-alcohols http://www.rsc.org/learn-chemistry/resource/res00000553/the-oxidation-of-alcohols </p>
KC4 / KC5 17.1b	(ii) classify hydroxy compounds into primary, secondary and tertiary alcohols (iii) suggest characteristic distinguishing reactions, e.g. mild oxidation	<ul style="list-style-type: none"> Learners make molecular models of isomers of alcohols with 3, 4 and 5 carbon atoms. Learners practise naming them (LO 14.1.a iii, b and 14.4.a). Learners group them according to their structure. Some will group them as primary, secondary and tertiary and so you can use these to explain this idea. Learners discuss in groups – what might be the products of each group after oxidation? Learners research what the products of these oxidations would be with potassium dichromate(VI). Provide worksheets with examples of primary, secondary and tertiary alcohols. Learners must <ul style="list-style-type: none"> decide which can be oxidised and which cannot name a suitable oxidising agent give visible observations state conditions and give formulae of products. (I) Extension activity: construct balanced chemical equations. (I) Peer-marking exercise using mark scheme prepared by you. <p> http://www.rsc.org/learn-chemistry/resource/res00000588/three-isomeric-alcohols </p>
KC2 / KC3 17.1c	Deduce the presence of a $\text{CH}_3\text{CH}(\text{OH})-$ group in an alcohol from its reaction	<ul style="list-style-type: none"> Learners investigation treating a variety of alcohols and carbonyl compounds with alkaline iodine: <ul style="list-style-type: none"> observing and describe results appropriately. Extension activity: deciding what the test tells them about the structure present. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	with alkaline aqueous iodine to form tri-iodomethane.	<ul style="list-style-type: none"> Provide worksheets with examples of alcohols, ketones and aldehydes. Learners must <ul style="list-style-type: none"> decide which will and which won't give positive iodoform test describe the testing reagent give visible observations give formulae of products. (I) Extension activity: construct balanced chemical equations. (I) Peer-marking exercise using mark scheme prepared by you.
KC2 / KC3 18.1a	Describe: <ul style="list-style-type: none"> (i) the formation of aldehydes and ketones from primary and secondary alcohols respectively using $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ (ii) the reduction of aldehydes and ketones, e.g. using NaBH_4 or LiAlH_4 (iii) the reaction of aldehydes and ketones with HCN and NaCN. 	<ul style="list-style-type: none"> Learners investigate these reactions practically e.g. Hill Practical 32 or Lainchbury Experiment 8.4. Learners create a mind map or table of these reactions; mind map links to alcohol reactions through the formation by oxidation and through carbonyl reduction. Learners add these reactions into mind maps / tables they are making of reaction types for oxidation, reduction and nucleophilic addition reactions. Provide worksheets with examples of ketones and aldehydes. Learners must: <ul style="list-style-type: none"> give a reaction by which each could be made give the product after treatment with NaBH_4 or LiAlH_4 give the product after treatment with HCN/KCN. (I) Extension activity: construct balanced chemical equations. (I) Peer-marking exercise using mark scheme prepared by you.
KC3 / KC4 18.1b	Describe the mechanism of the nucleophilic addition reactions of hydrogen cyanide with aldehydes and ketones.	<ul style="list-style-type: none"> You teach the nucleophilic addition mechanism with curly arrows etc. Learners choice of presentation to prepare <ul style="list-style-type: none"> Produce a poster describing the mechanism. Write and record/perform an interview involving the reacting species in which each must explain its role and what happens to it. Model this mechanism using molecular models and modelling clay (e.g. Plasticine, Blu-tack etc.) to represent lone pairs and bonds. Presentations are delivered and peer marked using mark scheme prepared by you. Learners then practise drawing out the mechanism followed by peer assessing each other's diagrams.
KC2 / KC3 18.1c	Describe the use of 2,4-dinitrophenylhydrazine	<ul style="list-style-type: none"> You teach the results of the addition of 2-4 DNPH to various carbonyl compounds. (Precipitates should be described as orange.)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	(2,4-DNPH) reagent to detect the presence of carbonyl compounds.	<ul style="list-style-type: none"> Learners decide what this test can tell them about a compound.
KC3 18.1d	Deduce the nature (aldehyde or ketone) of an unknown carbonyl compound from the results of simple tests (Fehling's and Tollens' reagents; ease of oxidation).	<ul style="list-style-type: none"> Learners investigate practically e.g. Practical Booklet 6, Lainchbury Experiment 8.5. Learners write up the practical with equations for all reactions. (I) <p>http://www.rsc.org/learn-chemistry/resource/res00000549/the-formation-of-solid-derivatives-of-aldehydes-and-ketones-using-2-4-dinitrophenylhydrazine-brady-s-test</p>
KC2 / KC3 18.1e	Describe the reaction of $\text{CH}_3\text{CO}-$ compounds with alkaline aqueous iodine to give tri-iodomethane.	<ul style="list-style-type: none"> Learners investigate practically. Learners write up the practical with equations for all reactions. (I) Provide worksheets with a wide variety of aldehydes and ketones and some alcohols. Learners must fill in: <ul style="list-style-type: none"> Observations with 2,4-DNPH Observations with Fehling's Observations with Tollens' Observations with alkaline iodine. (I) A balanced chemical equation for all reactions. (I) Peer-marking exercise using mark scheme prepared by you.
KC3 19.1a	Describe the formation of carboxylic acids from alcohols, aldehydes and nitriles.	<ul style="list-style-type: none"> You lead introductory Q&A to include: <ul style="list-style-type: none"> nature of functional group naming including dioic acids how $-\text{CO}_2\text{H}$ is shown in displayed formulae acidic nature of the $-\text{OH}$ proton only weak acid/partial dissociation conjugate acid/conjugate base pairs e.g. $\text{CH}_3\text{CO}_2\text{H}$ & CH_3CO_2^-. Learners brainstorm ways of making carboxylic acids. They should come up with <ul style="list-style-type: none"> oxidation of primary alcohols including reagents and conditions oxidation of aldehydes including reagents and conditions. You introduce hydrolysis of nitriles. Provide worksheets with a wide variety of carboxylic acids. Learners must fill in:

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
		<ul style="list-style-type: none"> ○ Three ways to make each one including reagents and conditions. (I) ○ A balanced chemical equation for all reactions. (I) ● Peer-marking exercise using mark scheme prepared by you.
KC2 / KC3 19.1b	Describe the reactions of carboxylic acids in the formation of: <ul style="list-style-type: none"> (i) salts, by the use of reactive metals, alkalis or carbonates (ii) alkyl esters (iii) alcohols, by use of LiAlH_4 	<ul style="list-style-type: none"> ● Learners investigate these reactions practically e.g. Hill Practical 33 or Lainchbury Experiment 10.1. ● Learners create a mind map or a table of these reactions that also links to other units' reactions such as alcohols. ● Provide worksheets with a wide variety of carboxylic acids. Learners must fill in: <ul style="list-style-type: none"> ○ Reactions with NaOH (aq) ○ Reactions with ethanol in the presence of a little conc. H_2SO_4 ○ Reactions with LiAlH_4. (I) ○ A balanced chemical equation for all reactions. (I) ● Peer-marking exercise using mark scheme prepared by you. <p> http://www.rsc.org/learn-chemistry/resource/res00000462/the-properties-of-ethanoic-acid http://www.rsc.org/learn-chemistry/resource/res00000561/the-preparation-of-ethyl-benzoate </p>
KC2 / KC3 / KC4 19.3a	Describe the acid and base hydrolysis of esters.	<ul style="list-style-type: none"> ● Learners could investigate the hydrolysis of esters practically and compare the ease of hydrolysis with <ul style="list-style-type: none"> ○ NaOH (aq) ○ H_2SO_4 (aq). ● Learners work in pairs. Learner 1 names an ester. Learners 2 works out the products of hydrolysis, saying which alcohol and which salt/acid are formed. Learners 1 and 2 then swap roles. ● Learners add these reactions to the mind maps of carboxylic acids and of alcohols. (I)
19.3b	State the major commercial uses of esters, e.g. solvents, perfumes, flavourings.	<ul style="list-style-type: none"> ● Learners each research the commercial uses of one ester. (I) ● Learners combine their findings into one table. ● You emphasise the three uses stated in the syllabus <ul style="list-style-type: none"> ○ solvents ○ perfumes ○ flavourings.
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support (F)		

5: Chemical trends 1

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC3 9.1a	Describe qualitatively (and indicate the periodicity in) the variations in atomic radius, ionic radius, melting point and electrical conductivity of the elements (see the <i>Data Booklet</i>).	<ul style="list-style-type: none"> • Quick quiz on the Periodic Table. • Learners should know from IGCSE <ul style="list-style-type: none"> ○ terminology such as Group and Period, ○ the location of areas such as metals, non-metals, alkali metals, halogens • Learners make models of the properties in this LO by <ul style="list-style-type: none"> ○ making different sized balls from modelling clay for atomic and ionic radius ○ cutting different lengths of wire for electrical conductivity (longer = greater conductivity), ○ building different number of Lego bricks in a tower to represent melting points ○ laying these on top of a Periodic Table. • You put sketches of graphs without labels on the board. Learners identify graphs, relate them to the 3-D representation, summarise today's learning on paper. • Learners also carry out practical work, such as Hill Practical 19, a practical study of the third Period.
KC3 9.1b	Explain qualitatively the variation in atomic radius and ionic radius.	<ul style="list-style-type: none"> • Learners talk together to decide which factors might make a difference to the size of atomic and ionic radius. • You pull these discussions together and make a check list of the factors they need to consider. • Provide worksheets using this list to explain why atomic radius decreases across a Period for example. (I)
KC3 / KC5 9.1c	Interpret the variation in melting point and electrical conductivity in terms of the presence of simple molecular, giant molecular or metallic bonding in the elements.	<ul style="list-style-type: none"> • You use the models of various types of structure that learners made in LO 4.3a to remind them of these types of bonding. • Learners allocate a colour to each type of structure and put stickers of the appropriate colour on each element in the first 6 rows of a copy of the Periodic Table. • Learners compare this to the models they made in 9.1a of melting point and electrical conductivity and discuss the patterns they can see. • The key concept of <i>energy changes</i> will be a helpful way for learners to think and write about these explanations.
KC1 / KC3 / KC5 2.3d	(i) explain and use the term <i>ionisation energy</i>	<ul style="list-style-type: none"> • Provide worksheets about Ionisation Energy (IE). To include: <ul style="list-style-type: none"> ○ the definition of 1st IE ○ the definition of 2nd IE and subsequent IEs ○ equations for 1st IE, 2nd IE and subsequent IEs

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	(ii) explain the factors influencing the ionisation energies of elements (iii) explain the trends in ionisation energies across a Period and down a Group of the Periodic Table (see also LOs 9.1).	<ul style="list-style-type: none"> the properties of atoms that make a difference to the size of 1st IE. <ul style="list-style-type: none"> nuclear charge distance from nucleus to outer shell shielding by inner-shell electrons spin-pair repulsion the first three of these properties applied to explain the decrease in 1st IE down a Group. Learners talk together in pairs about IE: <ul style="list-style-type: none"> in terms of the key concepts of atoms and forces, patterns in chemical behaviour and reactions, and energy changes, linking these ideas together in their discussions about the factors influencing the size of 1st IE, commenting on each other's ideas using mark scheme prepared by you, which is supplied after ten minutes.
KC3 / KC5 9.1d	Explain the variation in first ionisation energy (see the <i>Data Booklet</i>).	<ul style="list-style-type: none"> Learners plot graphs of the 1st IEs of the elements up to Ar. (I) Learners recognise and describe the pattern Li-Ne and Na-Ar. Learners talk together in pairs to explain this pattern using only <ul style="list-style-type: none"> nuclear charge distance shielding Extension activity: spin-pair repulsion. You provide a mark scheme which learners use to <ul style="list-style-type: none"> assess, criticise and correct their ideas produce a concise, correct explanation. Provide worksheets. Pairs of elements given, atoms are adjacent either vertically or horizontally e.g. <ul style="list-style-type: none"> Na and Mg Be and B F and Cl O and F P and S Li and Na Learners must predict which element has the higher 1st IE with as full an explanation as possible. (I) Peer-marking using mark scheme prepared by you.
KC1 / KC3 / KC5 2.3e	Deduce the electronic configurations of	<ul style="list-style-type: none"> Each learner gathers data to include all successive ionisation energies for one element. Use data from syllabus Data Book table 2, textbooks and/or online resources. (I) Learners in pairs exchange data and work out

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	elements from successive ionisation energy data.	<ul style="list-style-type: none"> the electronic configuration of the element its identity. Learners answer more challenging questions in Norris. (I) <p>http://en.wikipedia.org/wiki/Ionization_energies_of_the_elements_(data_page)</p>
KC1 / KC3 / KC5 2.3f	Interpret successive ionisation energy data of an element in terms of the position of that element within the Periodic Table.	<ul style="list-style-type: none"> Each learner gathers data on successive ionisation energies for one element. Use data from syllabus Data Book table 2, textbooks and/or online resources. (I) Learners in pairs exchange data and work out which Group of the Periodic Table the element is in. Learners then create a checklist of the steps needed to determine electron configuration and the position in the Periodic Table of an element from successive ionisation energy data. (I) Provide worksheet of problems, learners try each other's checklists out to see if they work. <p>http://en.wikipedia.org/wiki/Ionization_energies_of_the_elements_(data_page)</p>
KC2 / KC4 / KC5 9.2a	Describe the reactions, if any, of the elements with oxygen (to give Na ₂ O, MgO, Al ₂ O ₃ , P ₄ O ₁₀ , SO ₂ , SO ₃), chlorine (to give NaCl, MgCl ₂ , Al ₂ Cl ₆ , SiCl ₄ , PCl ₅) and water (Na and Mg only).	<ul style="list-style-type: none"> You demonstrate the reaction of: <ul style="list-style-type: none"> sodium, magnesium, phosphorus and sulfur in gas jars of oxygen, sodium, magnesium, phosphorus and sulfur in gas jars of chlorine sodium on water magnesium with steam. If you have any difficulties doing some or all of these experiments, then you could show video clips. Learners record observations and write equations. (I) Learners discuss: <ul style="list-style-type: none"> why elements may need to be heated first before being put in the gas jar, why some reactions are slower than others. This is a good revision activity as it brings together ideas about bonding and energy changes. (I) <p>http://www.rsc.org/learn-chemistry/resource/res00000706/ reacting-elements-with-chlorine</p>
KC3 9.2b	State and explain the variation in oxidation number of the oxides (sodium to sulfur only) and chlorides (sodium to phosphorus only) in terms	<ul style="list-style-type: none"> You put the formulae referred to in this LO on the board. <ul style="list-style-type: none"> Learners work out all of the oxidation numbers (LO 6.1.a). Learners put into one sentence what the trend in oxidation numbers is. Learners put into one sentence how this relates to the valence shell electrons. (I) Learners in pairs assess their partner's two sentences against the mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	of their valence shell electrons.	
KC2 / KC3 9.2c	Describe the reactions of the oxides with water (treatment of peroxides and superoxides is <i>not</i> required).	<ul style="list-style-type: none"> Learners investigate the Period 3 oxides' behaviour with water practically, e.g. Hill Practical 19 Experiment B or Lainchbury Experiment 4.14. Learners could then create a table to summarise these reactions. (I) Learners write equations for all that react and state acid/base trend. (I) Peer-marking of equations and trend using mark schemes prepared by you. <p>http://www.rsc.org/learn-chemistry/resource/res00001938/classic-chemistry-experiments-book</p>
KC2 / KC3 9.2d	Describe and explain the acid/base behaviour of oxides and hydroxides including, where relevant, amphoteric behaviour in reaction with acids and bases (sodium hydroxide only).	<ul style="list-style-type: none"> Learners' practical on the reactions of the oxides and hydroxides with NaOH and HCl. Learners write equations for all that react. (I) Peer-marking of equations and using mark scheme prepared by you. Learners state acid/base trend and compare to the trend observed from reaction with water. (I) Learners add this information to their summary table started in LO 9.2.c. (I)
KC2 / KC3 9.2e	Describe and explain the reactions of the chlorides with water.	<ul style="list-style-type: none"> Learners' practical Hill Practical 19 Experiment C Patterns in the properties of chlorides in Period 3. Learners write equations for all that react. (I) <ul style="list-style-type: none"> Equation for NaCl is $\text{NaCl} + \text{water} \rightarrow \text{NaCl}(\text{aq})$ Learners state acid/base trend. (I) Peer-marking of equations trend and using mark scheme prepared by you. Learners add this information to their summary table started in LO 9.2.c and d. (I)
KC3 / KC4 9.2f	Interpret the variations and trends in 9.2(b), (c), (d) and (e) in terms of bonding and electronegativity.	<ul style="list-style-type: none"> Learners add the bonding types and strength of electronegativity (LO 3.3.b) to the table(s) created in LO 9.2 c, d & e. (I) Learners use these to discuss the trends shown in pairs. Learners in pairs give short presentation to the group linking <ul style="list-style-type: none"> bonding types electronegativity of the Period 3 element acid/base nature of oxides acid/base nature of chlorides.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
		<ul style="list-style-type: none"> Peer assessment of presentations using mark scheme prepared by you.
KC3 / KC4 9.2g	Suggest the types of chemical bonding present in chlorides and oxides from observations of their chemical and physical properties.	<ul style="list-style-type: none"> Learners choose a chloride from Period 3 and write clues to its identity using its chemical and physical properties. (I) Each learner presents their clues to the rest of the class for them to say: <ul style="list-style-type: none"> what bonding is present. what its identity might be. Learners repeat the activity choosing an oxide from Period 3 Learners also complete more challenging questions e.g. those prepared by you or from textbook. (I)
KC4 9.1e	Explain the strength, high melting point and electrical insulating properties of ceramics in terms of their giant structure; to include magnesium oxide, aluminium oxide and silicon dioxide.	<ul style="list-style-type: none"> Learners research ceramics as described in this LO. (I) Learners deliver short presentation to the group. Peer-marking of presentations using mark scheme prepared by you.
KC3 9.3a	Predict the characteristic properties of an element in a given Group by using knowledge of chemical periodicity.	<ul style="list-style-type: none"> Provide worksheets requiring predictions of the chemical and physical properties of Rb, Sr, Ga, Ge, As, Se, Br and Kr. To include: <ul style="list-style-type: none"> Melting point Atomic radius (trend only) Ionic radius (trend only) Electrical conductivity Formula of, bonding in, acid base nature of oxide Formula of, bonding in, acid base nature of chloride Oxidation number in these compounds 1st ionisation energies. (I) Peer-marking of answers using mark scheme prepared by you. Mark scheme to include predictable responses based on the period 3 elements they have studied, and actual properties so learners can judge the accuracy of using the periodic table to make such predictions.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC3 9.3b	Deduce the nature, possible position in the Periodic Table and identity of unknown elements from given information about physical and chemical properties.	<ul style="list-style-type: none"> Learners choose an element and research its properties. Learners use properties to produce a set of clues that they believe will enable others to identify the element. (I) Learners present their clues to the rest of the class for them to try to identify the element.
KC2 / KC3 10.1a	Describe the reactions of the elements with oxygen, water and dilute acids.	<ul style="list-style-type: none"> Learners investigate the reactions of Group II metals with: <ul style="list-style-type: none"> water oxygen dilute acid e.g. Hill Practical 20, A practical study of Group II elements. Learners write up observations. (I) Provide worksheets with equation practice. (I) <p> http://www.rsc.org/learn-chemistry/resource/res00000728/the-reaction-of-magnesium-with-steam http://www.rsc.org/learn-chemistry/resource/res00000513/the-periodic-table-properties-of-group-2-elements </p>
KC2 / KC3 10.1b	Describe the behaviour of the oxides, hydroxides and carbonates with water and dilute acids.	<ul style="list-style-type: none"> Learners investigate these reactions practically, e.g. Hill Practical 20 Experiments 2 & 5. Learners make a table of all of this, along with LO 10.1.a, information, observations, equations and so on. Learners write up observations. (I) Provide worksheets with equation practice. (I)
KC2 / KC3 10.1c	Describe the thermal decomposition of the nitrates and carbonates.	<ul style="list-style-type: none"> Learners investigate these reactions practically, e.g. Hill practical 20 Experiment 4 or Lainchbury Experiment 4.2. Learners add this to the table they made in LO 10.1.b. (I) Learners write up observations. (I) Provide worksheets with equation practice. (I) Peer-marking exercise of worksheets used so far in this unit using mark schemes prepared by you.
KC3 10.1d	Interpret, and make predictions from, the trends in physical and chemical properties of the	<ul style="list-style-type: none"> You put some of the physical and chemical properties of Group 2 elements on the board. Learners work out which element corresponds to which set of clues.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	elements and their compounds.	
KC3 10.1e	State the variation in the solubilities of the hydroxides and sulfates.	<ul style="list-style-type: none"> Learners investigate these trends in solubilities practically. Learners to deduce the trends in solubility. Learners add this to their table of information from LOs 10.1a, b & c. (I)
10.2a	Describe and explain the use of calcium hydroxide and calcium carbonate (powdered limestone) in agriculture.	<ul style="list-style-type: none"> Learners research the agricultural uses of calcium hydroxide and calcium carbonate. Learners must sum up their findings in less than 250 words. (I)
KC5 11.1a	Describe the colours and the trend in volatility of chlorine, bromine and iodine.	<ul style="list-style-type: none"> You show a gas jar sample or find video clips of each of the elements F, Cl, Br and I. Learners should be able to see the evaporation of bromine to fill a closed vessel with orange vapour. You show the sublimation of iodine on warming in a fume cupboard to form purple vapour.
KC5 11.1b	Interpret the volatility of the elements in terms of van der Waals' forces.	<ul style="list-style-type: none"> Learners in pairs discuss for 1 minute everything they can remember about temporary dipole-induced dipole forces including what makes a difference to their size. You bring this together into Q&A about the observations made in 11.1a. Provide worksheets or use questions from textbooks. (I)
KC2 / KC3 / KC5 11.2a	Describe the relative reactivity of the elements as oxidising agents (see also Section 6.3.f).	<ul style="list-style-type: none"> Learners investigate practically by adding a solution of each element to a solution of each halide ion e.g. Lainchbury Experiment 4.6 or Hill Practical 21 Experiment 3. (You may already have used this experiment in LO 6.3 f). Learners write up observations. (I) Provide worksheets with equation practice. (I) Peer-marking exercise of worksheets using mark scheme prepared by you. <p>http://www.rsc.org/learn-chemistry/resource/res00000514/the-periodic-table-changes-down-the-group-7-elements</p>
KC3 11.2b	Describe and explain the reactions of the elements with hydrogen.	<ul style="list-style-type: none"> You show video clips of these reactions, such as those on rsc.org. Learners discuss what trend is shown and the reason(s) for it.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
		<ul style="list-style-type: none"> Learners write up observations. (I) Provide worksheets with equation practice. (I) <p>http://www.rsc.org/learn-chemistry/resource/res00001244/fire-and-flame-part-4#!cmpid=CMP00002394 clip 43 and 44</p>
KC3 / KC4 / KC5 11.2c	(i) describe and explain the relative thermal stabilities of the hydrides (ii) interpret these relative stabilities in terms of bond energies	<ul style="list-style-type: none"> Learners use the Data Booklet to look up the bond energies of the hydrogen-halogen bonds and use them to predict the trend in their thermal stabilities. You discuss the trend in the size of the halogen atoms. Provide worksheets about this thermal stability trend and its explanations. (I)
KC2 / KC3 11.3a	Describe and explain the reactions of halide ions with: (i) aqueous silver ions followed by aqueous ammonia (ii) concentrated sulfuric acid.	<ul style="list-style-type: none"> Learners investigate practically the colours of the precipitates formed with silver nitrate reacting with halide ions and subsequent addition of dilute ammonia and concentrated ammonia. (Lainchbury Experiment 4.8). You demonstrate the reactions of concentrated sulfuric acid with solutions of sodium chloride, sodium bromide and sodium iodide. Learners should: <ul style="list-style-type: none"> know the visible observations in each case interpret these reactions using oxidation numbers interpret these reactions in terms of increasing reducing strength of the halide ions going down the Group. Provide worksheets about these reactions, and their equations and trends. (I) Peer-marking of worksheets using mark scheme prepared by you. Learners answer questions in textbooks as practice question. (I)
KC5 11.4a	Describe and interpret, in terms of changes of oxidation number, the reaction of chlorine with cold and with hot	<ul style="list-style-type: none"> Provide worksheets to revisit oxidation numbers. You show the equations of chlorine reacting with hot and cold aqueous sodium hydroxide. Learners to work out all of the oxidation numbers. Learners should notice that chlorine has been both oxidised and reduced. You define and explain 'disproportionation'.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	aqueous sodium hydroxide.	
11.5a	Explain the use of chlorine in water purification.	<ul style="list-style-type: none"> You show how the pH of water changes when chlorine is added. Learners interpret using oxidation numbers and explain why this is disproportionation. Learners investigate chlorination of domestic water supplies. (I)
11.5.b	State the industrial importance and environmental significance of the halogens and their compounds (e.g. for bleaches, PVC, halogenated hydrocarbons as solvents, refrigerants and in aerosols. See also Section 16.2).	<ul style="list-style-type: none"> Learners research and produce a presentation on one or more of the use of halogens: <ul style="list-style-type: none"> (treating domestic water supplies could possibly be included here) for bleaches for PVC for halogenated hydrocarbon solvents as refrigerants in aerosols. (I) Learners deliver presentations which are peer-marked using mark scheme prepared by you.
KC4 / KC5 13.1a	Explain the lack of reactivity of nitrogen.	<ul style="list-style-type: none"> Learners draw a 'dot and cross' diagram for the bonding in a nitrogen molecule. Learners predict the size of the bond energy of this triple bond. Provide worksheets involving as many situations as you can include where nitrogen shows low reactivity. Learners should: <ul style="list-style-type: none"> use this worksheet to write a paragraph with as many examples as they can of the unreactivity of nitrogen. explain why nitrogen is unreactive by reference to the $\text{N}\equiv\text{N}$ bond and activation energy. (I)
KC2 / KC4 13.1b	Describe and explain: (i) the basicity of ammonia (see also LOs 7.2) (ii) the structure of the ammonium ion and its formation by an acid-base reaction	<ul style="list-style-type: none"> Learners' practical. A test tube containing some NH_3 (aq) and universal indicator which they then add HCl (aq) to. Learners make a molecular model of ammonia and the ammonium ion and draw 'dot and cross' diagrams of their bonding. Learners discuss in pairs the ammonium ion in terms of: <ul style="list-style-type: none"> the bonding present (LO 3.2.a ii) the bond angle proton transfer (7.2.a).

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	(iii) the displacement of ammonia from its salts.	<ul style="list-style-type: none"> Learners investigate ammonium salts practically heating them alone and with a base such as sodium or calcium hydroxide. Provide worksheets about the equations for these reactions. (I) Peer-marking of worksheets using mark scheme prepared by you.
13.1c	State the industrial importance of ammonia and nitrogen compounds derived from ammonia.	<ul style="list-style-type: none"> You start with quick quiz about the production of ammonia in the Haber process (LO 7.1.g). Learners research some uses of ammonia and other nitrogen compounds. (I)
13.1d	State and explain the environmental consequences of the uncontrolled use of nitrate fertilisers.	<ul style="list-style-type: none"> Learners research the uses of fertilisers and problems they can cause. (I)
13.1e	State and explain the natural and man-made occurrences of oxides of nitrogen and their catalytic removal from the exhaust gases of internal combustion engines.	<ul style="list-style-type: none"> Learners research car exhaust pollution and the effect of catalytic converters. (I)
13.1f	Explain why atmospheric oxides of nitrogen are pollutants, including their catalytic role in the oxidation of atmospheric sulfur dioxide (see also LO 8.3.e (iii)).	<ul style="list-style-type: none"> Learners research the role of SO₂ in acid rain and the reaction of NO₂ with SO₂ in the atmosphere. (I) Learners deliver presentations on 13.1c-f. Peer-marking of presentations using mark scheme prepared by you.
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support (F)		

6: Acids and bases

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
7.2c	Explain the terms pH, K_a , pK_a and K_w and use them in calculations.	<ul style="list-style-type: none"> Learners research one of these terms. (I) Learners deliver presentations. Extension activity: Peer-marking of presentations using mark scheme prepared by you. Learners' practical work. Hill Practical 10 Experiment 3. <p>Practical Booklet 8</p>
7.2d	Calculate $[H^+(aq)]$ and pH values for strong and weak acids and strong bases.	<ul style="list-style-type: none"> You teach the three methods. Provide worksheet for learners to practise examples. Learners write up the methods. Learners in pairs explain their method, with discussion/criticism from their peers. Learners' practical work Lainchbury Experiment 7.2 'The pH of different acids at the same concentration.' Learners write up practical, explaining the pH values using what they have learnt. (I)
7.2e	Explain the choice of suitable indicators for acid-base titrations, given appropriate data.	<ul style="list-style-type: none"> You show a range of indicators and their colours in weak and strong acids and alkalis. Provide worksheet on how to choose an indicator for various pairs of acids and bases given the end point pH for each titration. Extension activity: Learners complete Hill Practical 10 Experiment 4. Learners write up practical. (I) <p>Practical Booklet 8</p>
KC2 / KC4 7.2f	Describe the changes in pH during acid-base titrations and explain these changes in terms of the strengths of the acids and bases.	<ul style="list-style-type: none"> Learners carry out titrations of weak and strong acids and bases (in the 4 possible combinations) and plot pH curves for them using a pH meter or sensor and data logging if available. Lainchbury experiments 7.4 and 7.6 are examples you could use for experiments to do. Learners practise drawing the shape of pH curves and combine this with LO 7.2.e to look at indicator choice. Provide worksheet showing the shapes of curves and asking: <ul style="list-style-type: none"> which combination of acid and base is represented? what are the volumes of acid and base present at the end point? what indicator should be used? (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
		<ul style="list-style-type: none"> Peer-marking of worksheets using mark scheme prepared by you. Practical Booklet 8
KC2 7.2g	(i) Explain how buffer solutions control pH. (ii) Describe and explain the uses of buffer solutions, including the role of HCO_3^- in controlling pH in blood.	<ul style="list-style-type: none"> Learner's practical work to investigate a buffer solution such as in Lainchbury Experiment 7.3. Learners to research different uses of buffer solutions one of which should be the role of the hydrogen carbonate ions in buffering blood. Learners deliver presentations. Peer-marking of presentations using mark scheme prepared by you.
KC2 7.2h	Calculate the pH of buffer solutions, given appropriate data.	<ul style="list-style-type: none"> Learner's practical work, e.g. Lainchbury Experiment 7.7 'Preparation of buffers'. Learners use combinations of 1.0 mol dm^{-3} ammonia solution, 1.0 mol dm^{-3} ethanoic acid, 1.0 mol dm^{-3} ammonium chloride solution and 1.0 mol dm^{-3} sodium ethanoate solution to prepare solutions of precise pH (e.g. 5.2 and 8.8). You use these buffers as a context to explain how to calculate the pH of a buffer. Provide worksheets for calculating the pH of given buffer solutions and creating buffer solutions for given pH. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC2 7.2i	Show understanding of, and use, the concept of solubility product, K_{sp} .	<ul style="list-style-type: none"> Learner's practical work to establish some 'rules' about the solubility of different ionic solids (e.g. all nitrates are soluble) using for example Lainchbury Experiment 4.3 'The solubility of some salts of Group II elements'. You put this practical work in the context of the analysis part of paper 3. You teach the concept of solubility product, K_{sp}. Learners write equilibrium expressions for the salts they have investigated and research values of K_{sp}.
7.2j	Calculate K_{sp} from concentrations and vice versa.	<ul style="list-style-type: none"> You use the examples from the practical work in 7.2.j (as well as others) to teach the method for these calculations. Provide worksheets. What is: <ul style="list-style-type: none"> K_{sp} given saturated concentrations of both ions? solubility given K_{sp}? the concentration of the other ion given K_{sp} and the concentration of one ion? (I) Peer-marking of worksheets using mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC2 7.2k	Show understanding of the common ion effect.	<ul style="list-style-type: none">• You show that calcium hydroxide precipitates out when you add 2.0 mol dm^{-3} sodium hydroxide solution to saturated calcium hydroxide solution.• You ask learners why this happens in terms of the K_{sp} expression.• You ask learners to suggest how to cause precipitation for other solutions.• Learners test their predictions practically (or you could demonstrate them).• Learners' practical, e.g. Lainchbury Experiment 6.4 'Illustrating the common ion effect'.• Learners write up practical. (I)
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support (F)		

7: Electricity and metals

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC1 6.2a	State and apply the relationship $F = Le$ between the Faraday constant, the Avogadro constant and the charge on the electron.	<ul style="list-style-type: none"> Learners talk in pairs to recall prior learning of Avogadro's constant. You teach and explain the relationship of $F=Le$. Provide worksheet for practicing using $F=Le$. (I) Peer-marking of worksheets using mark scheme prepared by you. <p>www.s-cool.co.uk Electrochemistry http://www.rsc.org/learn-chemistry/resource/res00001883/quantitative-electrolysis-of-aqueous-copper-ii-sulfate</p>
KC5 6.2b	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.	<ul style="list-style-type: none"> Learners in pairs discuss learning the reactivity series from IGCSE/O Level, comparing it to the tables in section 4 of the <i>Data Booklet</i> (in syllabus). Learners research about what influences whether a substance is discharged (or not) at an electrode. It is being suggested that this is to be done before the study of E^\ominus begins. You will need to give guidance of this type: <ul style="list-style-type: none"> positive ions are easier to discharge if E^\ominus is more positive. negative ions are easier to discharge if E^\ominus is more negative. Learners present an electrolysis example to the class with emphasis on why the products are what they are at the cathode and anode. Electrolysis of: <ul style="list-style-type: none"> aluminium oxide (l) sodium chloride (aq) and (l), sulfuric acid (aq) sodium sulfate(aq). Learners' practical work <ul style="list-style-type: none"> Hutchings experiments 7, 15 and 82. Hill also has a planning practise L3 'Electrolysis of salt solution' Lainchbury experiment 7.11 'Testing predictions about redox reactions'. Learners write up practical work. (I) <p>http://www.rsc.org/learn-chemistry/resource/res00000392/electricity-from-chemicals http://www.rsc.org/learn-chemistry/resource/res00000399/chemistry-and-electricity http://www.rsc.org/learn-chemistry/resource/res00000466/the-electrolysis-of-solutions</p>

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC1 6.2c	Calculate: (i) the quantity of charge passed during electrolysis (ii) the mass and/or volume of substance liberated during electrolysis, including those in the electrolysis of $\text{H}_2\text{SO}_4(\text{aq})$ and of $\text{Na}_2\text{SO}_4(\text{aq})$.	<ul style="list-style-type: none"> Learners' practical work to investigate the change in mass of the copper anode during the electrolysis of copper sulfate solution. Learners verify the relationship between the current, the time passed, and the change in mass. Learners write up practical. (I) Provide worksheets for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you. <p> http://www.rsc.org/learn-chemistry/resource/res00000392/electricity-from-chemicals http://www.rsc.org/learn-chemistry/resource/res00000399/chemistry-and-electricity http://www.rsc.org/learn-chemistry/resource/res00000466/the-electrolysis-of-solutions </p>
KC1 / KC2 6.2d	Describe the determination of a value of the Avogadro constant by an electrolytic method.	<ul style="list-style-type: none"> Learners carry out electrolysis of copper sulfate solution with copper electrodes to determine Avogadro's constant. Learners write up practical. (I) <p>http://www.rsc.org/learn-chemistry/resource/res00001883/quantitative-electrolysis-of-aqueous-copper-ii-sulfate</p>
KC2 / KC5 6.3a	Define the terms: (i) <i>standard electrode (redox) potential</i> (ii) <i>standard cell potential</i> .	<ul style="list-style-type: none"> Learners investigate practically, half cells and combinations of them, e.g. $\text{Zn}(\text{s})$ in $\text{Zn}^{2+}(\text{aq})$, $\text{Cu}(\text{s})$ in $\text{Cu}^{2+}(\text{aq})$ and $\text{Ag}(\text{s})$ in $\text{Ag}^+(\text{aq})$. See Lainchbury Experiment 7.10 for an example. You explain the origin of the voltages: <ul style="list-style-type: none"> electrons are moving from one half cell to another One volt means the energy change when one coulomb of charge has moved is one joule. You discuss with learners the factors that might affect the voltages. You explain: <ul style="list-style-type: none"> the standard conditions that are chosen the need for a standard electrode in order to measure the 'standard electrode potential' of a half-cell the term 'standard cell potential'.
6.3b	Describe the standard hydrogen electrode.	<ul style="list-style-type: none"> Learners research the standard hydrogen electrode. (I) Provide worksheets on standard conditions and SHEs. (I) Peer-marking of worksheets using mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC2 / KC5 6.3c	Describe methods used to measure the standard electrode potentials of: (i) metals or non-metals in contact with their ions in aqueous solution (ii) ions of the same element in different oxidation states.	<ul style="list-style-type: none"> Learners' practical work, using a variety of half cells of the metal electrode in a solution containing ions of that metal, e.g.: <ul style="list-style-type: none"> Fe/Fe²⁺ (aq) Ag/Ag⁺ (aq) Cu/Cu²⁺ (aq) Zn/Zn²⁺ (aq) Mg/Mg²⁺ (aq). Extend to include: <ul style="list-style-type: none"> platinum electrode in contact with I⁻ and I₂ (aq), graphite can be used if Pt is unavailable. platinum electrode in contact with Fe²⁺ and Fe³⁺ (aq). Learners see how they can make cells using a combination of half cells. Provide worksheets for practising examples of labelled diagrams of cells and how to represent them with standard shorthand notation. (I) Peer-marking of worksheets using mark scheme prepared by you. <p>Practical Booklet 7</p>
KC5 6.3d	Calculate a standard cell potential by combining two standard electrode potentials.	<ul style="list-style-type: none"> Learners predict the cell potential they would expect to measure when they combine two half cells. Learners test their predictions. Helpful practicals include: <ul style="list-style-type: none"> Hill Practical 11, 'Electrochemical cells', Lainchbury Experiments 7.10 and 7.13. Provide worksheet for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you. <p>Practical Booklet 7</p>
KC5 6.3e	Use standard cell potentials to: (i) explain/deduce the direction of electron flow in a simple cell (ii) predict the feasibility of a reaction.	<ul style="list-style-type: none"> Learners discuss in groups some of the cells they have investigated practically and their respective E^{\ominus} values to decide what the sign of the E^{\ominus} means. Each group feeds back their discussion to the whole group. The key concept of energy changes could help learners to understand the idea of feasibility. Provide worksheets for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you. Learners' practical, e.g. Lainchbury Experiment 7.11, to supplement this learning. Learners write up practical. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC5 6.3f	Deduce from E^\ominus values the relative reactivity of elements of Group 17 (the halogens) as oxidising agents.	<ul style="list-style-type: none"> You show again the displacement reactions of halogens e.g. Lainchbury Experiment 4.6 Halogen-halide reactions in aqueous solution as evidence of the relative oxidising powers. Learners find the relevant E^\ominus data (<i>Data Booklet</i> (in the syllabus). (I)) Learners state the relationship between oxidising power and E^\ominus. You teach how to use E^\ominus values to predict the outcome of reactions where oxidising agents and reducing agents are present e.g.: <ul style="list-style-type: none"> will Fe^{3+} oxidise I^- ions to iodine? will Fe^{3+} oxidise Br^- ions to bromine? Provide worksheets for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC5 6.3g	Construct redox equations using the relevant half-equations (see also LO 12.2.d).	<ul style="list-style-type: none"> You teach how to use half-equations to construct a redox equation: <ul style="list-style-type: none"> predicting which reactions will occur using E^\ominus values (see last lesson) reversing the half-equation where oxidation occurs producing balanced equations using the numbers of electrons in the two half-equations. Learners work in pairs to create a checklist of the steps they need to take to be able to construct redox equations and then practise writing them using it. Provide worksheets for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC2 12.2d	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 LO 6.3).	<ul style="list-style-type: none"> Learners' practical e.g.: <ul style="list-style-type: none"> titration, Lainchbury Experiment 1.6 (ammonium iron(II) sulfate solution with potassium manganate(VII) solution) titration Hill Practical 3 Analysing iron tablets organic context, using reflux with acidified potassium dichromate(VI) as an oxidising agent of for example alcohols to become carbonyls/carboxylic acids Lainchbury Experiment 8.1 Chemical properties of ethanol Hill Practical 30 Alcohols Experiment 3. Provide worksheets for practising examples of combining half equations to construct (ionic) equations. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC5 12.2e	Predict, using E^\ominus values, the likelihood of redox reactions.	<ul style="list-style-type: none"> You teach a summary of the strength of <ul style="list-style-type: none"> oxidising agents in terms of large positive E^\ominus values e.g. $\text{MnO}_4^-/\text{H}^+$ (aq) reducing agents in terms of large negative E^\ominus values e.g. Mg. Provide worksheets for practising more examples of:

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
		<ul style="list-style-type: none"> ○ using E^\ominus values to predict outcomes ○ combining half equations to construct (ionic) equations. (I) ● Peer-marking of worksheets using mark scheme prepared by you.
KC2 / KC5 6.3h	Predict qualitatively how the value of an electrode potential varies with the concentrations of the aqueous ions.	<ul style="list-style-type: none"> ● Learners' practical work investigating this relationship e.g.: <ul style="list-style-type: none"> ○ Hill Practical 11 experiment 4 ○ Lainchbury Experiment 7.12. ● Learners use their results to make general conclusions about the relationship. ● Learners write up practical. (I) <p>Practical Booklet 7</p>
KC5 6.3i	Use the Nernst equation, e.g. $E = E^\ominus + (0.059/z) \log \frac{[\text{oxidised species}]}{[\text{reduced species}]}$ to predict quantitatively how the value of an electrode potential varies with the concentrations of the aqueous ions; examples include $\text{Cu(s)} + 2\text{e}^- \rightleftharpoons \text{Cu}^{2+}(\text{aq})$, $\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightleftharpoons \text{Fe}^{2+}(\text{aq})$, $\text{Cl}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-(\text{aq})$	<ul style="list-style-type: none"> ● You explain the Nernst equation. ● Provide worksheets for practising examples of calculating E values for non-standard concentrations. (I) ● Peer-marking of worksheets using mark scheme prepared by you.
KC5 6.4a	State the possible advantages of developing other types of cell, e.g. the H_2/O_2 fuel cell and the nickel-metal hydride and lithium-ion rechargeable batteries.	<ul style="list-style-type: none"> ● Learners research about batteries and fuel cells with an emphasis on why they are used in terms of size, mass and voltage. To include: <ul style="list-style-type: none"> ○ H_2/O_2 fuel cells ○ nickel-metal hydride rechargeable batteries ○ lithium-ion batteries. (I) ● Learners deliver presentations. ● Peer-marking of presentations using mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC1 12.1a	Explain what is meant by a <i>transition element</i> , in terms of d-block elements forming one or more stable ions with incomplete d orbitals.	<ul style="list-style-type: none"> You teach what is meant by a transition element. Learners revisit electron configuration (LO 2.3.c), writing the electron configurations of the first set of transition elements, Ti to Cu. Learners then move on to ions such as Fe^{2+}, Fe^{3+}, Cr^{3+}, Cu^{2+} for example.
KC1 12.1b	Sketch the shape of a d orbital.	<ul style="list-style-type: none"> Learners draw and label the five orbitals in the 3d subshell. (I)
KC1 12.1c	State the electronic configuration of each of the first row transition elements and of their ions.	<ul style="list-style-type: none"> Provide worksheets for practising examples of electron configurations of atoms and ions. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC3 12.1d	Contrast, qualitatively, the melting points and densities of the transition elements with those of calcium as a typical s-block element.	<ul style="list-style-type: none"> Learners provided with the melting point and density data for calcium and for the first row of transition elements. Learners make general comparisons of these properties. (I)
KC2 12.1e	Describe the tendency of transition elements to have variable oxidation states.	<ul style="list-style-type: none"> Learners' practical work in which they see the same transition element in various oxidation states e.g. <ul style="list-style-type: none"> Hill Practical 22 The oxidation state of vanadium and manganese Lainchbury Experiments 11.4 and 11.5. Learners write up practical. (I) <p> www.s-cool.co.uk http://www.rsc.org/learn-chemistry/resource/res00001350/chemistry-vignettes-transition-metal-fundamentals#!cmpid=CMP00002896 </p>
KC3 12.1f	Predict from a given electronic configuration,	<ul style="list-style-type: none"> You teach the pattern of oxidation states of transition elements:

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	the likely oxidation states of a transition element.	<ul style="list-style-type: none"> the maximum oxidation states are +4 at Ti rising to +7 at Mn falling to +3 at Cu in the shape of a triangle all from Ti to Cu have a +2 state all from Ti to Ni show the oxidation states in between +2 and their maximum oxidation state Cu also has a +1 state. <ul style="list-style-type: none"> Learners produce a chart of oxidation states of the elements Ti to Cu. (I) <p>http://elementalolympics.files.wordpress.com/2011/02/variable-oxidation-states.png</p>
KC4 12.2a	Describe and explain the reactions of transition elements with ligands to form complexes, including the complexes of copper(II) and cobalt(II) ions with water and ammonia molecules and hydroxide and chloride ions.	<ul style="list-style-type: none"> Learners research the meanings of ligands and complexes. Learners deliver presentations. Peer-marking of presentations using mark scheme prepared by you. Learners' practical work with Cu(II), Co(II) and ligands, e.g. Lainchbury Experiment 11.6 Relative stabilities of some complex ions. Learners' practical investigating the chemical test for water with anhydrous cobalt chloride paper. Learners write up practical. (I) <p>http://www.rsc.org/learn-chemistry/resource/res00000116/afl-transition-metal-complexes</p>
KC4 12.2b	<p>(i) Define the term <i>ligand</i> as a species that contains a lone pair of electrons that forms a dative bond to a central metal atom/ion including monodentate, bidentate and polydentate ligands.</p> <p>(ii) Define the term <i>complex</i> as a molecule or ion formed by a central metal atom/ion</p>	<ul style="list-style-type: none"> Provide worksheets with a term and definition word-match activity which includes: <ul style="list-style-type: none"> ligand complex monodentate bidentate polydentate co-ordination number. Learners discuss the way that shapes of molecules are determined (LO 3.2.b). Provide worksheets for predicting the shapes of transition metal complexes. (I) Peer-marking of worksheets using mark scheme prepared by you. Provide worksheets for practising: <ul style="list-style-type: none"> working out the charges on complex ions drawing shapes stating bond-angles. (I) Peer-marking of worksheets using mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	<p>surrounded by one or more ligands.</p> <p>(iii) Describe transition metal complexes as linear, octahedral, tetrahedral or square planar.</p> <p>(iv) State what is meant by co-ordination number and predict the formula and charge of a complex ion, given the metal ion, its charge, the ligand and its co-ordination number.</p>	<p>http://www.rsc.org/learn-chemistry/resource/res00000658/cobalt-complexes</p>
KC2 12.2c	Explain qualitatively that ligand exchange may occur, including the complexes of copper(II) ions with water and ammonia molecules and hydroxide and chloride ions.	<ul style="list-style-type: none"> Learners' practical work showing the addition of ammonia and concentrated HCl to hydrated copper ions and observing the colour changes. Learners write up practical. (I) <p>Practical Booklet 9</p>
KC1 12.3a	Describe the splitting of degenerate d orbitals into two energy levels in octahedral and tetrahedral complexes.	<ul style="list-style-type: none"> Give learners choices: <ul style="list-style-type: none"> produce a poster to explain d orbital splitting. script and record an interview with the five d orbitals of a transition metal ion as they are approached by 4 or 6 ligands. produce a physical representation where they take five sticks or planes at the same height, then introduce the 4 or 6 ligands, then the five planes split into two groups. Learners deliver presentations. V and K learners must explain their presentations. Peer-marking of presentations using mark scheme prepared by you. Written piece 'Describe d orbital splitting in transition element complexes and explain how it arises'. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC1 12.3b	Explain the origin of colour in transition element complexes resulting from the absorption of light energy as an electron moves between two non-degenerate d orbitals.	<ul style="list-style-type: none"> Give learners choices: <ul style="list-style-type: none"> produce a poster to explain the origin of colour in complexes of transition metal ions. script and record an interview with the d orbital electrons and the transition metal ion as they are lit by white light. produce a physical representation of what happens to the d orbital electrons when the complex is lit by white light. You will need to support and guide, ensuring the key factors of light absorption and electron promotion are given due prominence. Learners deliver presentations. V and K learners must explain their presentations. Peer-marking of presentations using mark scheme prepared by you. Written piece 'Explain the origin of colour in complexes of transition metal ions.' (I)
KC1 / KC5 12.3c	Describe, in qualitative terms, the effects of different ligands on absorption, and hence colour, using the complexes of copper(II) ions with water and ammonia molecules and hydroxide and chloride ions as examples.	<ul style="list-style-type: none"> Learners discuss how the size of ΔE might affect colour. You discuss their opinions with them and introduce the idea that different ligands split the d orbitals by different amounts. You demonstrate adding ammonia and concentrated HCl to $\text{Cu}^{2+}(\text{aq})$ and go over the explanation for the colour changes with the learners. Provide worksheets for practising explanations for: <ul style="list-style-type: none"> what we mean by d orbital splitting why transition metal complexes are coloured why ligand replacement causes a colour change. (I) Peer-marking of worksheets using mark scheme prepared by you. <p>Practical Booklet 9</p>
KC2 12.3d	Apply the above ideas of ligands and complexes to other metals, given information.	<ul style="list-style-type: none"> Provide worksheets giving examples of the formation of complexes of other transition metals (i.e. in addition to Cu). (I) Peer-marking of worksheets using mark scheme prepared by you.
12.5a	Describe and explain ligand exchanges in terms of competing equilibria (also see syllabus topic 7).	<ul style="list-style-type: none"> Learners revisit practical work, <ul style="list-style-type: none"> Relative stabilities of some complex ions of copper the equilibrium of hydrated cobalt chloride with its anhydrous form. Learners write equilibrium expressions for these complex formations. <p>Practical Booklet 9</p>

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
12.5b	State that the stability constant, K_{stab} , of a complex ion is the equilibrium constant for the formation of the complex ion in a solvent from its constituent ions or molecules.	<ul style="list-style-type: none"> Learners revisit a K_c calculation. Learners use their equilibrium expressions for complex formations and produce K_{stab} expressions.
KC4 12.5c	Deduce expressions for the stability constant of a ligand substitution.	<ul style="list-style-type: none"> Learners write equilibrium expressions for the substitution of a water ligand by a chloride ion or ammonia ligands with copper for example, and then deduce their respective K_{stab} expressions. Provide worksheets for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC4 12.5d	Explain ligand exchange in terms of stability constants, K_{stab} , and understand that a large K_{stab} is due to the formation of a stable complex ion.	<ul style="list-style-type: none"> Learners discuss in pairs what the relative size of stability constants means. Learners come together and present their ideas to the class, led by you.
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support (F)		

8: Controlling reactions 2

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC4 / KC5 5.1b	<i>Lattice energy</i> (ΔH negative, i.e. gaseous ions to solid lattice).	<ul style="list-style-type: none"> You define lattice enthalpy and explain its significance to ionic bond strength, melting points, solubility. You introduce the difficulty in measuring lattice enthalpy directly.
KC1 / KC3 / KC5 2.3g	Explain and use the term <i>electron affinity</i> .	<ul style="list-style-type: none"> Learners find definition of electron affinity. Learners produce a revision list of all definitions encountered so far in the course. (I)
KC1 / KC4 / KC5 5.1d	Explain, in qualitative terms, the effect of ionic charge and of ionic radius on the numerical magnitude of a lattice energy.	<ul style="list-style-type: none"> Learners research how the size of the ions and the size of the charges will cause the force of attraction in a lattice to change. Learners deliver presentations. Peer-marking of presentations using mark scheme prepared by you.
KC4 / KC5 5.2a	<p>The formation of a simple ionic solid and of its aqueous solution.</p> <p>Born-Haber cycles (including ionisation energy and electron affinity).</p>	<ul style="list-style-type: none"> You teach how to construct a Born-Haber cycle. Provide worksheets for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you. You teach enthalpy of solution as it relates to lattice enthalpy and enthalpy of hydration. Learners' discussion of how solubility changes with respect to lattice energy and enthalpy change of hydration. Learners' practical work to determine the enthalpy changes of solution for solids such as sodium hydroxide, ammonium nitrate etc.; see Hill Practical 9.
KC4 / KC5 10.1f	Interpret and explain qualitatively the trend in the thermal stability of the nitrates and carbonates in terms of the charge density of the cation and	<ul style="list-style-type: none"> You recap the trend from 10.1.c. Learners given choice: <ul style="list-style-type: none"> explain the reasons for the trend in stability in a poster. script and record a conversation between the metal ions and the nitrate and carbonate ions in which the reasons for the trend in stability are made clear.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	the polarisability of the large anion.	<ul style="list-style-type: none"> ○ make models of the ions of Group II metals and nitrate ions and carbonate ions, from modelling clay. The polarisation of the nitrate and carbonate ions by the different sized metal ions should be shown. ● Learners deliver presentations. ● Peer-marking of presentations using mark scheme prepared by you.
KC1 / KC4 / KC5 10.1g	Interpret and explain qualitatively the variation in solubility of the hydroxides and sulfates in terms of relative magnitudes of the enthalpy change of hydration and the corresponding lattice energy.	<ul style="list-style-type: none"> ● You lead Q&A about the factors that affect lattice energy (LO 5.1.d) and hydration energy and about the trend in solubility of Group II hydroxides and sulfates (LO 10.1.e). ● Learners given choice: <ul style="list-style-type: none"> ○ explain the reasons for the trends in solubility in a poster. ○ script and record a conversation between the metal ions and the hydroxide and sulfate ions in which the reasons for the trends in solubility are made clear. ○ make models of the ions of Group II metals and hydroxide ions and sulfate ions, from modelling clay. ● Learners deliver presentations. Kinaesthetic learners will have to add a commentary to explain why the sizes of the ions they've modelled are significant. ● Peer-marking of presentations using mark scheme prepared by you. ● Learners practise questions either provided by you or from textbook. (I)
KC5 5.3a	Explain that entropy is a measure of the 'disorder' of a system, and that a system becomes more stable when its energy is spread out in a more disordered state.	<ul style="list-style-type: none"> ● You introduce the idea of entropy as a measure of disorder: <ul style="list-style-type: none"> ○ with the symbol S ○ change in entropy during a chemical or physical change is ΔS ○ solids are more ordered and have least entropy ○ gases are more disordered and have most entropy ○ entropy increases when solids dissolve to form solutions.
KC5 5.3b	Explain the entropy changes that occur: (i) during a change in state e.g. (s) \rightarrow (l); (l) \rightarrow (g); (s) \rightarrow (aq) (ii) during a temperature change	<ul style="list-style-type: none"> ● Learners research into whether entropy increases or decreases: <ul style="list-style-type: none"> ○ during a change of state ○ during a temperature change ○ during a reaction that changes the number of gas molecules. ● Learners deliver presentations. ● Peer-marking of presentations using mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	(iii) during a reaction in which there is a change in the number of gaseous molecules.	
KC5 5.3c	Predict whether the entropy change for a given process is positive or negative.	<ul style="list-style-type: none"> • Provide worksheets for practising examples of predicting the sign of ΔS. (I) • Peer-marking of worksheets using mark scheme prepared by you. • Extension activity: Learners then work in pairs to create situations for their peers to predict the sign of the entropy change.
KC5 5.3d	Calculate the entropy change for a reaction, ΔS^\ominus , given the standard entropies, S^\ominus , of the reactants and products.	<ul style="list-style-type: none"> • You explain the method. • Provide worksheets for practising examples of calculating ΔS from supplied entropy values. (I) • Peer-marking of worksheets using mark scheme prepared by you. • Learners' research – what is Gibbs Free Energy? (I)
KC5 5.4a	Define standard Gibbs free energy change of reaction by means of the equation $\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$.	<ul style="list-style-type: none"> • Learners bring to the lesson the results of their research about Gibbs Free Energy. (I) • You emphasise: the importance of: <ul style="list-style-type: none"> ○ the Gibbs equation ○ the sign of ΔG^\ominus ○ a zero value of ΔG^\ominus. • Learners discuss the Gibbs equation, what the terms mean and the significance of ΔG^\ominus. • Learners summarise what they have learned today. (I) • Peer-marking of homework using mark scheme prepared by you.
KC5 5.4b	Calculate ΔG^\ominus for a reaction using the equation $\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$	<ul style="list-style-type: none"> • You introduce how to calculate a ΔG^\ominus value from data. • Provide worksheets for practising examples. (I) • Peer-marking of worksheets using mark scheme prepared by you.
KC5 5.4c	State whether a reaction or process will be	<ul style="list-style-type: none"> • Provide worksheets for practising examples to include the significance of the sign of ΔG^\ominus. (I) • Peer-marking of worksheets using mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	spontaneous by using the sign of ΔG^\ominus	
KC5 5.4d	Predict the effect of temperature change on the spontaneity of a reaction, given standard enthalpy and entropy changes.	<ul style="list-style-type: none"> Provide worksheets for practising examples to bring together: <ul style="list-style-type: none"> the effect of varying temperature. how varying temperature can affect the sign of ΔG^\ominus. what this means for the spontaneity of a reaction at different temperatures. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC3 8.1c	Explain and use the terms <i>rate equation</i> , <i>order of reaction</i> , <i>rate constant</i> , <i>half-life of a reaction</i> , <i>rate-determining step</i> .	<ul style="list-style-type: none"> Learners research each of these terms. Learners deliver presentations. Peer-marking of presentations using mark scheme prepared by you. The main learning of each of these terms will occur as they are used in the correct context during the following lessons, but this exercise will be valuable preparation for that.
KC3 8.1d	Construct and use rate equations of the form $\text{rate} = k[\text{A}]^m[\text{B}]^n$ (for which m and n are 0, 1 or 2), including: <ul style="list-style-type: none"> (i) deducing the order of a reaction, or the rate equation for a reaction, from concentration-time graphs or from experimental data relating to the initial rates method and half-life method (ii) interpreting experimental data in graphical form, including 	<ul style="list-style-type: none"> You teach the construction and use of rate equations. Learners' practical work. Learners follow the rate of reaction: <ul style="list-style-type: none"> by collecting gas from reactions such as: <ul style="list-style-type: none"> calcium carbonate with hydrochloric acid benzenediazonium chloride and water Lainchbury Experiment 9.4, by colorimetry such as: <ul style="list-style-type: none"> iodine and propanone Lainchbury Experiment 9.5, colour change of starch when hydrogen peroxide reacts with iodide ions (Hill Practical 15) by formation of a precipitate such as: <ul style="list-style-type: none"> the 'disappearing cross' when sodium thiosulfate reacts with hydrochloric acid. You discuss practical work with learners in terms of orders of reaction and where possible learners suggest rate equations. Provide worksheets for practising examples of graphical work to include: <ul style="list-style-type: none"> plotting graphs drawing the appropriate line drawing tangents to measure rate deciding if the half-life of a reactant is constant the interpretation of rate-concentration graphs. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	concentration-time and rate-concentration graphs (iii) calculating an initial rate using concentration data (integrated forms of rate equations are not required).	<ul style="list-style-type: none"> Peer-marking of worksheets using mark scheme prepared by you. <p> http://www.rsc.org/learn-chemistry/resource/res00000567/finding-the-rate-expression-for-the-reaction-between-iodine-and-tin http://www.rsc.org/learn-chemistry/resource/res00000598/a-chemical-stop-clock-iodine-clock-reaction </p>
8.1e	(i) Show understanding that the half-life of a first-order reaction is independent of concentration. (ii) Use the half-life of a first-order reaction in calculations.	<ul style="list-style-type: none"> Provide worksheets for practising examples of: <ul style="list-style-type: none"> assessing whether a half-life is constant calculating the half life using the half-life in calculations. (I) Peer-marking of worksheets using mark scheme prepared by you. <p> http://www.rsc.org/learn-chemistry/resource/res00000743/the-effect-of-concentration-on-reaction-rate </p>
8.1f	Calculate the numerical value of a rate constant, for example by using the initial rates or half-life method.	<ul style="list-style-type: none"> Provide worksheets for practising examples of: <ul style="list-style-type: none"> deriving and writing rate equations from supplied data. determining the units of a rate constant calculating the value of a rate constant. using $k = \ln 2 / t_{1/2}$ for first order reactions. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC3 8.1g	For a multi-step reaction: (i) suggest a reaction mechanism that is consistent with the rate equation and the equation for the overall reaction	<ul style="list-style-type: none"> You introduce the idea of the rate-determining step with a demonstration of passing an object along the row of learners. <ul style="list-style-type: none"> All pass it normally except one who keeps it for 30 seconds before passing. Time how long the whole process takes. Repeat, the normal passers try to speed up, the slow passer still takes 30 seconds. Time how long the whole process takes. Repeat; the normal passers all pass it normally; the slow passer speeds up to the same rate as the others. Time how long the whole process takes.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	(ii) predict the order that would result from a given reaction mechanism (and vice versa).	<ul style="list-style-type: none"> ○ Discuss. Learners should conclude that the slow step has a much greater influence on the rate than the fast steps. ● You use the reaction of iodine and propanone as context. Use the rate equation $\text{rate} = k[\text{propanone}][\text{H}^+]$ to discuss and explain how it links to the mechanism. <ul style="list-style-type: none"> ○ Slow step – propanone isomerises to enol form with C=C double bond. Propanone and H^+ are involved. ○ Fast step – enol form reacts with I_2. ● Learners look at a number of reactions and discuss in groups the links between the orders of reaction of each species, the rate equation and the mechanism of the reaction. Examples of reactions that you could use are: <ul style="list-style-type: none"> ○ $2\text{N}_2\text{O}_5 \rightarrow 4\text{NO}_2 + \text{O}_2$, ○ Bromine + propanone, ○ acidified hydrogen peroxide and iodide ions ○ the alkaline hydrolysis of 2-bromomethylpropane. ● Cann p.219 shows a helpful worked example. (I) ● Provide worksheets for practising examples. This WS is easiest to write if you fabricate examples using symbols e.g.: <ul style="list-style-type: none"> ○ $\text{AB} + \text{C} \rightarrow \text{AC} + \text{B}$ and $\text{Rate} = k[\text{AB}]$ ○ $\text{PQ} + \text{R} \rightarrow \text{PR} + \text{Q}$ and $\text{Rate} = k[\text{R}^2]$ ○ Learners must suggest a mechanism consistent with this information. ○ If you add some fabricated data learners can also use this to practise calculating the value of k. (I) ● Peer-marking of worksheets using mark scheme prepared by you.
KC2 8.1h	Devise a suitable experimental technique for studying the rate of a reaction, from given information.	<ul style="list-style-type: none"> ● Learners prepare plans ‘How to study the rate of a reaction’ to present to the class. You could have more than one plan for each experiment. Choose a variety of reactions that lend themselves to different ways of monitoring such as: <ul style="list-style-type: none"> ○ collecting gas ○ change in mass ○ change in colour ○ sampling (including titrating of those samples) ● Learners deliver presentations. ● Peer-marking of presentations using mark scheme prepared by you.
8.2c	Explain qualitatively the effect of temperature	<ul style="list-style-type: none"> ● You teach: <ul style="list-style-type: none"> ○ the rate constant is a constant whatever the concentrations

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	change on a rate constant and hence the rate of a reaction.	<ul style="list-style-type: none">○ the rate constant is not constant if conditions are changed.● Class discussion – how does T affect k?
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support (F)		

9: Organic chemistry 2

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC1 14.1a	<p>Interpret and use the general, structural, displayed and skeletal formulae of the following classes of compound:</p> <ul style="list-style-type: none"> • arenes • halogenoarenes • phenols • acyl chlorides • amino acids <p>(Candidates will be expected to recognise the shape of the benzene ring when it is present in organic compounds. Knowledge of benzene or its compounds is <i>not</i> required for AS Level.)</p>	<ul style="list-style-type: none"> • You revisit 14.1.a (AS), and include the A Level compounds. • Learners in pairs make a variety of molecular models, with some from each of the classes listed in this LO. • Learners use these to practise drawing the general, structural, displayed and skeletal formulae for each molecule. • Provide worksheets for practising examples of drawing different types of formulae. (I) • Peer-marking of worksheets using mark scheme prepared by you.
KC1 / KC3 / KC4 15.4a	<p>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>	<ul style="list-style-type: none"> • You revisit LO 14.3 regarding the shape of organic compounds including benzene • You introduce arenes including: <ul style="list-style-type: none"> ○ behaviour ○ bonding and the delocalisation of electrons around the ring. ○ models showing the shape and bonding. • Learners' practical e.g. Hill Practical 27. • Learners make a mind map or table of these reactions of benzene and methylbenzene. • Learners summarise: <ul style="list-style-type: none"> ○ reactions, conditions, type of reaction, and equation ○ compare the same reaction for benzene with that for methylbenzene. • Provide worksheets for practising examples of reactions of benzene and methylbenzene. (I)

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	(iii) Friedel-Crafts alkylation and acylation (iv) complete oxidation of the side-chain to give a benzoic acid (v) hydrogenation of the benzene ring to form a cyclohexane ring.	<ul style="list-style-type: none"> Peer-marking of worksheets using mark scheme prepared by you. (P) (F) (Basic) <p>http://www.rsc.org/learn-chemistry/resource/res00000286/organic-molecules-day</p>
KC1 / KC3 / KC4 15.4b	(i) Describe the mechanism of electrophilic substitution in arenes, as exemplified by the formation of nitrobenzene and bromobenzene. (ii) Suggest the mechanism of other electrophilic substitution reactions, given data. (iii) Describe the effect of the delocalisation of electrons in arenes in such reactions.	<ul style="list-style-type: none"> Learners talk in pairs to define free radical, electrophile, nucleophile, addition, substitution. Give learners choices: <ul style="list-style-type: none"> produce a poster to explain electrophilic substitution. script and record an interview with the benzene ring and the attacking species. produce a physical representation using molecular models and modelling clay (e.g. Plasticine or Blu-tack) to represent the delocalised electrons and the electron pairs. Learners deliver presentations. V and K learners must explain their presentations. Peer-marking of presentations using mark scheme prepared by you. Provide worksheets for practising examples of electrophilic substitution mechanism. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC1 / KC3 / KC4 15.4c	Interpret the difference in reactivity between benzene and chlorobenzene.	<ul style="list-style-type: none"> Learners sketch the electron density cloud for benzene and chlorobenzene. Learners talk in pairs to produce ideas to present to the group: <ul style="list-style-type: none"> what effect will the chlorine atom have on the electron density in the ring? what effect will this have on the reactivity of the ring towards electrophiles? Learners present ideas to the group, you guide them to reach correct conclusion.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
		<ul style="list-style-type: none"> Learners' written piece (to use this lesson plus research) 'Comparing the reactivity of benzene and chlorobenzene with electrophiles'. (I)
KC3 15.4d	Predict whether halogenation will occur in the side-chain or in the aromatic ring in arenes depending on reaction conditions.	<ul style="list-style-type: none"> You teach the conditions under which halogenation occurs in: <ul style="list-style-type: none"> the ring the side chain. Provide worksheets for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC3 15.4e	Apply knowledge relating to position of substitution in the electrophilic substitution of arenes (see the syllabus <i>Data Booklet</i> Table 9).	<ul style="list-style-type: none"> You teach how substituents on the ring affect subsequent substitutions, see syllabus page 90. Provide worksheets for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you.
14.1c	Understand and use systematic nomenclature of simple aromatic molecules with one benzene ring and one or more simple substituents, for example 3-nitrobenzoic acid, 2,4,6-tribromophenol.	<ul style="list-style-type: none"> You explain the naming convention. Provide worksheets for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC2 / KC3 17.2a	Recall the chemistry of phenol, as exemplified by the following reactions: <ul style="list-style-type: none"> (i) with bases (ii) with sodium (iii) with diazonium salts (see also Section 20.1) 	<ul style="list-style-type: none"> Learners investigate practically e.g. Hill Practical 31 or Lainchbury Experiment 8.2. Learners create a mind map or table of these reactions. Provide worksheets for practising examples. Compare, contrast and explain the reactions of phenol with those of benzene and methylbenzene, especially: <ul style="list-style-type: none"> the nitration and bromination substitution reactions. (I) Peer-marking of worksheets using mark scheme prepared by you. <p>http://www.rsc.org/learn-chemistry/resource/res00000547/the-chemical-properties-of-hydroxybenzene</p>

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	(iv) nitration of, and bromination of, the aromatic ring.	
KC2 17.2b	Describe and explain the relative acidities of water, phenol and ethanol.	<ul style="list-style-type: none"> You revisit calculating $[H^{+}]$ from pH and pH from $[H^{+}]$. Learners write equilibrium expressions for the dissociation of water, phenol, and ethanol. Learners' practical testing water and solutions of phenol, and ethanol with universal indicator. You compare acidity of water and ethanol using sodium metal. Learners talk in pairs: <ul style="list-style-type: none"> what is the order of acidity? what is the reason for it? Learners describe evidence and explain reasons for homework. (I)
19.1b	Describe the reactions of carboxylic acids in the formation of: acyl chlorides.	<ul style="list-style-type: none"> You revisit 19.1.b, introducing (iv) which may not have been covered as part of the AS course. <p>www.s-cool.co.uk</p>
KC3 19.1c	Recognise that some carboxylic acids can be further oxidised: (i) the oxidation of methanoic acid, HCO_2H , with Fehling's and Tollens' reagents (ii) the oxidation of ethanedioic acid, HO_2CCO_2H , with warm acidified manganate(VII).	<ul style="list-style-type: none"> You introduce the reactions in which methanoic acid and ethanedioic acid can be oxidised. Learners' practical titrating ethanedioic acid against acidified MnO_4^{-}. Provide worksheets for practising examples and equations for reactions of carboxylic acids to include oxidation of methanoic acid and ethanedioic acid. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC3 19.1d	Explain the relative acidities of carboxylic	<ul style="list-style-type: none"> Learners research into relative acidity of carboxylic acids, phenols, and alcohols. To include: <ul style="list-style-type: none"> examples of reactions with equations

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	acids, phenols and alcohols.	<ul style="list-style-type: none"> ○ pK_a values ○ explanation. (I) • Learners deliver presentations. • Peer-marking of presentations using mark scheme prepared by you.
KC4 / KC5 19.1e	Use the concept of electronegativity to explain the acidities of chlorine-substituted ethanoic acids.	<ul style="list-style-type: none"> • You can include this piece of research and presentation alongside 19.1.d. • Learners research into relative acidity of ethanoic acid and chlorine-substituted ethanoic acids. To include: <ul style="list-style-type: none"> ○ pK_a values ○ explanation involving electronegativity. (I) • Learners deliver presentations. • Peer-marking of presentations using mark scheme prepared by you.
KC2 19.2a	Describe the hydrolysis of acyl chlorides.	<ul style="list-style-type: none"> • You demonstrate this practically, e.g. Lainchbury Experiment 10.2. • Learners write up practical with observations and equations. (I)
KC2 / KC3 19.2b	Describe the reactions of acyl chlorides with alcohols, phenols, ammonia and primary amines.	<ul style="list-style-type: none"> • You demonstrate these reactions practically. • Learners write up practical with observations and equations. (I) • Learners' paired work, each learner describes a reaction of a named acid chloride, their partner has to write the observations and equation. Learners then change roles until at least two of each reaction in 19.2 a and b have been covered.
KC3 17.1a	Recall the chemistry of alcohols, exemplified by ethanol, in the following reactions: formation of esters by acylation with acyl chlorides using ethyl ethanoate and phenyl benzoate as examples.	<ul style="list-style-type: none"> • Learners extend paired work from previous lesson to include reaction of acid chlorides to form ethyl ethanoate and phenyl benzoate.
19.2c	Explain the relative ease of hydrolysis of acyl chlorides, alkyl chlorides and aryl chlorides	<ul style="list-style-type: none"> • You show the equations with conditions for the hydrolysis of ethanoyl chloride to form ethanoic acid and for chloroethane to form ethanol. • Learners brainstorm reasons why acid chlorides are easier to hydrolyse than halogenoalkanes, which are easier to hydrolyse than aryl chlorides (e.g. chlorobenzene).

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	including the condensation (addition elimination) mechanism for the hydrolysis of acyl chlorides.	<ul style="list-style-type: none"> Learners discuss their ideas and rank them from the most to the least likely / possible. You bring this together and also teach the addition / elimination mechanism. Provide worksheets for practising examples of hydrolysis reactions and explaining relative ease of hydrolysis. (I) Peer-marking of worksheets using mark scheme prepared by you.
20.1a	Describe the formation of alkyl amines such as ethylamine (by the reaction of ammonia with halogenoalkanes; the reduction of amides with LiAlH_4 ; the reduction of nitriles with LiAlH_4 or H_2/Ni) and of phenylamine (by the reduction of nitrobenzene with tin/ concentrated HCl).	<ul style="list-style-type: none"> Learners research the methods of forming amines. To include: <ul style="list-style-type: none"> preparation of ethylamine and phenylamine equations conditions video clips if possible Learners deliver presentations. Peer-marking of presentations using mark scheme prepared by you. <p>http://www.youtube.com/watch?v=oRn7kTiqfaA</p>
KC3 20.1b	Describe and explain the basicity of amines.	<ul style="list-style-type: none"> Give learners choices: <ul style="list-style-type: none"> produce a poster to explain why amines are basic. script and record an interview with an amine and a hydrogen ion. produce a physical representation using molecular models and blu-tack for lone pairs. Learners deliver presentations; visual and kinaesthetic learners will need to explain their presentations. Peer-marking of presentations using mark scheme prepared by you.
KC1 / KC3 / KC4 20.1c	Explain the relative basicities of ammonia, ethylamine and phenylamine in terms of their structures.	<ul style="list-style-type: none"> Learners brainstorm what factors will affect basicity. Brainstormed ideas brought together. You lead discussion to a correct conclusion. Provide worksheets for practising examples. To include: <ul style="list-style-type: none"> formation of amines reason for basicity of amines relative basicity of amines. (I) Peer-marking of worksheets using mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC2 20.1d	Describe the reaction of phenylamine with: (i) aqueous bromine (ii) nitrous acid to give the diazonium salt and phenol.	<ul style="list-style-type: none"> Learners investigate practically e.g. Hill Practical 34 or Lainchbury Experiment 8.3. Learners write up practicals. (I)
KC2 20.1e	Describe the coupling of benzenediazonium chloride and phenol and the use of similar reactions in the formation of dyestuff.	<ul style="list-style-type: none"> Learners investigate practically. Learners write up practical, including: <ul style="list-style-type: none"> the conditions with reasons observations equations the use of the product as a dye. (I) Provide worksheets for practising examples of reactions of phenylamine. (I) Peer-marking of worksheets using mark scheme prepared by you. <p>http://www.rsc.org/learn-chemistry/resource/res00000559/the-microscale-synthesis-of-azo-dyes</p>
20.2a	Describe the formation of amides from the reaction between NH_3 or RNH_2 and $\text{R}'\text{COCl}$.	<ul style="list-style-type: none"> You teach this as a whole group activity.
KC1 / KC3 20.2b	Recognise that amides are neutral.	<ul style="list-style-type: none"> You show various amides in solution in test tubes and add indicator to them. You explain why the structure does not accept a proton easily on the NH_2 group (and so is not basic) and why it does not release a proton easily (and so is not acidic).
KC3 20.2c	(i) Describe amide hydrolysis on treatment with aqueous alkali or acid. (ii) Describe the reduction of amides with LiAlH_4	<ul style="list-style-type: none"> Learners investigate practically, refluxing an amide with hydrochloric acid and/or sodium hydroxide solution (separately). Learners research products of amide hydrolysis and the reduction of amides to nitriles. Learners deliver presentations. Peer-marking of presentations using mark scheme prepared by you. Provide worksheets for practising questions on amides. (I) Peer-marking of worksheets using mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC1 / KC4 20.3a	Describe the acid/base properties of amino acids and the formation of zwitterions.	<ul style="list-style-type: none"> Learners make molecular models of various amino acids such as alanine, valine and glycine. Learners discuss why amino acids can be both acids and bases. Learners draw out the structures of amino acids in acidic and basic environments and at the isoelectric point (the zwitterion).
KC4 20.3b	Describe the formation of peptide bonds between amino acids to give di- and tri-peptides.	<ul style="list-style-type: none"> You explain formation of peptide bonds. Learners use models of amino acids made last lesson to model formation of di-peptides and tri-peptides.
KC1 20.3c	Describe simply the process of electrophoresis and the effect of pH, using peptides and amino acids as examples.	<ul style="list-style-type: none"> Learners create a simulation <ul style="list-style-type: none"> five pieces of paper, each one is an amino acid (one each of lysine, glutamic acid, glycine, leucine and phenylalanine) they are put in the middle of the table, one side is positive, the opposite side is negative, the pH is 7 lysine goes to negative side, glutamic acid goes to positive side, others stay in the middle, you explain why. the pH now becomes 12. You discuss what happens with the learners, due to magnitude of charge and molecular mass. Learners 'run the simulation'. the pH now becomes 2. You discuss what happens with the learners, due to magnitude of charge and molecular mass. Learners 'run the simulation'. Learners discuss what effects pH has on the movement of amino acids in an electric field. Provide worksheets for practising questions about amino acids. (I) Peer-marking of worksheets using mark scheme prepared by you.
8.3e	Outline the different characteristics and modes of action of homogeneous, heterogeneous and enzyme catalysts, including: (i) the Haber process (ii) the catalytic removal of oxides of nitrogen from the exhaust	<ul style="list-style-type: none"> You reintroduce all catalysts in their contexts from LO 7.1.g, 8.1.d, 15.3.b (i), and 13.1.f and use as examples of homogeneous and heterogeneous catalysts. Learners given choice: <ul style="list-style-type: none"> produce a poster to explain enzyme action. script and record a conversation between the enzyme and its substrate. make models of enzyme and substrate and show how the enzyme works. Learners deliver presentations. Kinaesthetic and visual learners should introduce their presentations. Peer-marking of presentations using mark scheme prepared by you. Provide worksheets for practising recalling and describing these examples of catalysis. Peer-marking of worksheets using mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	gases of car engines (see also LO 15.3.b(i)) (iii) the catalytic role of atmospheric oxides of nitrogen in the oxidation of atmospheric sulfur dioxide (see also LO 13.1.f) (iv) the catalytic role of Fe^{2+} or Fe^{3+} in the $\text{I}^-/\text{S}_2\text{O}_8^{2-}$ reaction (v) the catalytic role of enzymes (including the explanation of specificity using a simple lock and key model but excluding inhibition).	
KC1 23.1a	State that most chiral drugs extracted from natural sources often contain only a single optical isomer.	<ul style="list-style-type: none"> • Learners research: <ul style="list-style-type: none"> ○ the idea of one optical isomer being a better form of a drug than another. ○ problems that have arisen due to chiral drugs. • Learners deliver presentations.
KC1 12.4a	Describe the types of stereoisomerism shown by complexes, including those associated with bidentate ligands: (i) cis-trans isomerism, e.g. cis- and trans-platin $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$	<ul style="list-style-type: none"> • Learners make models of these complexes and then draw the structures in of the platins in 2D and the optical isomers in 3D.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	(ii) optical isomerism, e.g. $[\text{Ni}(\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2)_3]^{2+}$	
12.4b	Describe the use of cisplatin as an anticancer drug and its action by binding to DNA in cancer cells, preventing cell division.	<ul style="list-style-type: none"> Learners could research the action of cisplatin as a chemotherapy drug and present their findings in less than 250 words. (I) www.cisplatin.org
21.1a	Describe the formation of polyesters and polyamides.	<ul style="list-style-type: none"> Learners use molecular models of amino acids to form a long chain model of a polypeptide, forming a peptide bond each time 2 monomer units are joined together. Learners repeat this to show formation of polyesters and polyamides. Provide worksheets for practising examples. To include: <ul style="list-style-type: none"> polyesters polyamides polypeptides Peer-marking of worksheets using mark scheme prepared by you. http://www.rsc.org/learn-chemistry/resource/res00000755/making-nylon-the-nylon-rope-trick
KC3 21.1b	Describe the characteristics of condensation polymerisation; (i) in polyesters as exemplified by <i>Terylene</i> (ii) in polyamides as exemplified by polypeptides, proteins, nylon 6, nylon 6,6 and <i>Kevlar</i>	<ul style="list-style-type: none"> Learners reflect on work from last lesson and discuss characteristics of condensation polymerisation and summarise in 250 words.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
21.1.c	Deduce the repeat unit of a condensation polymer obtained from a given monomer or pair of monomers.	<ul style="list-style-type: none"> Learners each invent condensation polymer and draw the monomer(s). Learners swap monomers and deduce the repeat unit of the polymer. Continue this exercise with other pairings.
21.1d	Identify the monomer(s) present in a given section of a condensation polymer molecule.	<ul style="list-style-type: none"> Learners each invent condensation polymer and draw the repeat unit. Learners swap repeat units and deduce the monomer(s). Continue this exercise with other pairings. Provide worksheets for practising examples. To include: <ul style="list-style-type: none"> deducing the repeat unit from the monomer(s) deducing the monomer(s) from the repeat unit. Peer-marking of worksheets using mark scheme prepared by you.
21.2a	Predict the type of polymerisation reaction for a given monomer or pair of monomers.	<ul style="list-style-type: none"> Learners work in pairs to create a checklist of what to look for in the monomer(s) for each type of polymerisation.
21.2b	Deduce the type of polymerisation reaction which produces a given section of a polymer molecule.	<ul style="list-style-type: none"> Provide worksheets for practising examples. To include: <ul style="list-style-type: none"> deducing the type of polymerisation from the monomer(s) deducing the type of polymerisation from the repeat unit. Peer-marking of worksheets using mark scheme prepared by you.
KC1 / KC2 21.3a	Discuss the properties and structure of polymers based on their methods of formation (addition or condensation, see also Section 15.2).	<ul style="list-style-type: none"> You show samples of various polymers labelled with their name, repeat unit and polymerisation type. Learners do some basic tests and observations, such as tensile strength test, flexibility and density, e.g. Hill Practical 35 Experiment B. Learners discuss their observations in pairs to look for patterns in properties and types of polymerisation.
KC1 / KC4 21.3b	Discuss how the presence of side-chains and intermolecular forces affect the properties of	<ul style="list-style-type: none"> Learners research into the factors that affect the properties of polymers. To include: <ul style="list-style-type: none"> side chains/branching molecular mass attractive forces between chains

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	polymeric materials (e.g. polyalkenes, PTFE (<i>Teflon</i>), <i>Kevlar</i>).	<ul style="list-style-type: none"> ○ PTFE and Kevlar • Learners deliver presentations. • Peer-marking of presentations using mark scheme prepared by you. <p> http://www.rsc.org/learn-chemistry/resource/res00000385/identifying-polymers http://www.rsc.org/learn-chemistry/resource/res00000756/pva-polymer-slime </p>
KC1 / KC4 21.3c	Explain the significance of hydrogen-bonding in the pairing of bases in DNA in relation to the replication of genetic information.	<ul style="list-style-type: none"> • You ask those learners who also take Cambridge International A Level Biology to present the chemistry of DNA's structure and the idea of 'unzipping' of the double helix during replication. • Learners deduce which type of bonding would allow this 'unzipping' to happen. • Learners look at the pairing of bases in DNA to see how this occurs.
KC4 21.4a	Recognise that polyalkenes are chemically inert and can therefore be difficult to biodegrade.	<ul style="list-style-type: none"> • You make a model of a section of a polythene chain and ask learners to compare it to an alkane of between 10 and 20 carbon atoms. • You then ask them to predict the reactivity of polythene from their knowledge of alkanes (LO 15.1.a). • Learners explain the unreactivity of poly(alkenes) based on the unreactivity of the C-C and C-H bonds. (I)
KC4 21.4b	Recognise that a number of polymers can be degraded by the action of light.	<ul style="list-style-type: none"> • Learners research into the development of <i>photodegradable polymers</i> (e.g. an internet search). • Learners deliver presentations. • Peer-marking of presentations using mark scheme prepared by you.
KC4 21.4c	Recognise that polyesters and polyamides are biodegradable by hydrolysis.	<ul style="list-style-type: none"> • Learners write an equation for the acid hydrolysis of an ester, e.g. propyl butanoate, and an amide e.g. N-ethyl butanamide. • Learners research into the <i>hydrolysis of polyesters</i> and the <i>hydrolysis of polyamides</i> (e.g. an internet search). • Learners deliver presentations. • Peer-marking of presentations using mark scheme prepared by you.
21.4d	Describe the hydrolysis of proteins.	<ul style="list-style-type: none"> • You perform demonstration practical. • You then separate the amino acids by electrophoresis.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
		<ul style="list-style-type: none"> If you don't have the necessary apparatus then learners could research into the acidic, alkaline, and enzymatic hydrolysis of proteins followed by: <ul style="list-style-type: none"> Learners deliver presentations. Peer-marking of presentations using mark scheme prepared by you. Provide worksheets for practising questions on degradable polymers. To include: <ul style="list-style-type: none"> why polyalkenes are inert photodegradability hydrolysis of, polyesters, polyamides, proteins. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC1 / KC2 / KC3 23.2a	For an organic molecule containing several functional groups: (i) identify organic functional groups using the reactions in the syllabus (ii) predict properties and reactions.	<ul style="list-style-type: none"> You produce molecular models with several functional groups and a worksheet to go with each model. Learners must: <ul style="list-style-type: none"> identify all functional groups decide how the molecule will react with a range of reagents. Peer-marking of worksheets using mark scheme prepared by you. <p>http://www.rsc.org/learn-chemistry/resource/res00000003/synthesis-explorer</p>
KC1 / KC2 / KC3 23.2b	Devise multi-stage synthetic routes for preparing organic molecules using the reactions in the syllabus.	<ul style="list-style-type: none"> Learners use the various mind maps and tables that they have made for the summary of reactions of each type of functional group. You give a starting molecule and a finishing molecule. Learners work out what reactions (reagents, conditions etc.) would get them from the start to the finish. Provide worksheets for practising examples. Learners should learn to use a variety of approaches: <ul style="list-style-type: none"> working forward from the starting material working backward from the final product suggesting a reaction (that may not prove helpful), to see if this gets them to a more promising place, and being prepared to try again if it doesn't. (I) Peer-marking of worksheets using mark scheme prepared by you.
23.2c	Analyse a given synthetic route in terms of type of reaction and reagents	<ul style="list-style-type: none"> Provide worksheets for practising examples of multi-step syntheses. Learners must: <ul style="list-style-type: none"> name the types of reaction name the reagents that would be used give essential conditions

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	used for each step of it, and possible by-products.	<ul style="list-style-type: none"> ○ identify any by-products. (I) ● Peer-marking of worksheets using mark scheme prepared by you. <p>http://www.rsc.org/learn-chemistry/resource/res00000849/synthesis-and-analysis</p>
KC4 21.3d	Distinguish between the primary, secondary (α -helix and β -sheet) and tertiary structures of proteins and explain the stabilisation of secondary structure (through hydrogen bonding between C=O and N–H bonds of peptide groups) and tertiary structure (through interactions between R-groups).	<ul style="list-style-type: none"> ● Learners research into proteins including: <ul style="list-style-type: none"> ○ primary structure ○ two secondary (α-helix and β-sheet) structures and the forces that stabilise them ○ tertiary structure and the R-group interactions that stabilise it. ● Learners deliver presentations. ● Peer-marking of presentations using mark scheme prepared by you.
21.3e	Describe how polymers have been designed to act as: (i) non-solvent based adhesives, e.g. epoxy resins and superglues (ii) conducting polymers, e.g. polyacetylene.	<ul style="list-style-type: none"> ● Learners research into: <ul style="list-style-type: none"> ○ non-solvent based adhesives such as epoxy resins and superglues ○ conducting polymers such as polyacetylene. ● Learners deliver presentations. ● Peer-marking of presentations using mark scheme prepared by you. <p> http://www.specialchem4adhesives.com/home/editorial.aspx?id=232 http://en.wikipedia.org/wiki/Cyanoacrylate http://en.wikipedia.org/wiki/Polyacetylene </p>
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support (F)		

10: Analysis

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC1 22.3a	Deduce the molecular mass of an organic molecule from the molecular ion peak in a mass spectrum.	<ul style="list-style-type: none"> You explain how to deduce the M_r value from a mass spectrum. Learners practise identifying the molecular ion peak. Search online for 'mass spectrum images' for examples. (I) <p>http://www.rsc.org/learn-chemistry/resource/res00000943/spectroscopy-in-a-suitcase-mass-spectrometry-teacher-resources</p>
KC1 22.3b	Deduce the number of carbon atoms in a compound using the M+1 peak.	<ul style="list-style-type: none"> You teach the significance of the M+1 peak and explain the method. Provide worksheets for practising calculating the number of carbon atoms. Peer-marking of worksheets using mark scheme prepared by you.
KC1 22.3c	Deduce the presence of bromine and chlorine atoms in a compound using the M+2 peak.	<ul style="list-style-type: none"> You teach the significance of M+2 peaks and explain the relative heights of M:M+2 that indicate: <ul style="list-style-type: none"> chlorine 3:1 bromine 1:1. Provide worksheets for practising recognising the presence of chlorine and bromine. Peer-marking of worksheets using mark scheme prepared by you.
KC1 / KC4 22.3d	Suggest the identity of molecules formed by simple fragmentation in a given mass spectrum.	<ul style="list-style-type: none"> You teach the concept of fragmentation. Learners draw structures and predict the fragments formed from simple molecules e.g. <ul style="list-style-type: none"> isomers of C_6H_{14} isomers of C_4H_8O Learners combine what they've learnt so far as they practise making deductions about the molecules that produce the spectra they are given. Learners create a checklist of the order in which to make deductions e.g.: <ul style="list-style-type: none"> Look at the molecular ion peak Calculate the number of carbon atoms from M+1 peak Look for presence of chlorine or bromine Identify fragments and match to possible structures. Provide worksheets for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
KC4 22.1a	Explain and use the terms <i>R_f value</i> in thin layer chromatography and <i>retention time</i> in gas/liquid chromatography from chromatograms.	<ul style="list-style-type: none"> Learners' practical work separating individual amino acids from a mixture of them, e.g. Lainchbury Experiment 10.7 (See also LO 20.3.c and 21.4.c). (I) You arrange a visit to a local university or industrial company that has a GLC machine (you might combine this with other analysis techniques). Provide worksheets for practising examples. To include: <ul style="list-style-type: none"> working out <i>R_f</i> values identifying substances using <i>R_f</i> values. (I) Peer-marking of worksheets using mark scheme prepared by you. <p> http://www.rsc.org/learn-chemistry/resource/res00001301/chromatography http://www.rsc.org/learn-chemistry/resource/res00000582/as-sweet-as-detecting-aspartame-in-a-table-top-sweetener </p>
22.1b	Interpret gas/liquid chromatograms in terms of the percentage composition of a mixture.	<ul style="list-style-type: none"> Learners practise calculating the areas of the (approximately) triangular peaks to estimate the proportion of components in the mixture. They use traces brought back from the visit and compare their calculations with the automatically calculated print out proportions that most GLC machines provide. (I) Provide worksheets for practising examples. Peer-marking of worksheets using mark scheme prepared by you.
KC4 7.3a	State what is meant by partition coefficient; calculate and use a partition coefficient for a system in which the solute is in the same molecular state in the two solvents.	<ul style="list-style-type: none"> Learners' practical work showing how a solute can be distributed between two solvents e.g. iodine between water and hexane. You explain the meaning of partition coefficient. Learners determine a partition coefficient such as in Lainchbury Experiment 6.5 Distributing 1.0 M ammonia between water and an organic solvent (Volasil 244 in this case). Provide worksheets for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC1 22.4a	Analyse a carbon-13 NMR spectrum of a simple molecule to deduce: (i) the different environments of the carbon atoms present	<ul style="list-style-type: none"> You show a number of ¹³C spectra and explain how to interpret them to determine the environments of carbon atoms and then possible structures. Provide worksheets for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
	(ii) the possible structures for the molecule.	
KC1 22.4b	Predict the number of peaks in a carbon-13 NMR spectrum for a given molecule.	<ul style="list-style-type: none"> You show learners a variety of organic molecules and ask them in pairs to discuss what environments exist for the carbon atoms that are present. Provide worksheets for practising examples. (I) Peer-marking of worksheets using mark scheme prepared by you.
KC1 22.5a	Analyse and interpret a proton NMR spectrum of a simple molecule to deduce: <ul style="list-style-type: none"> (i) the different types of proton present using chemical shift values (ii) the relative numbers of each type of proton present from relative peak areas (iii) the number of non-equivalent protons adjacent to a given proton from the splitting pattern, using the $n + 1$ rule (iv) the possible structures for the molecule. 	<ul style="list-style-type: none"> You arrange a visit to see an NMR spectrometer in action and see what sort of spectra it produces. You use these spectra and/or any others from textbooks / websites, to explain how to interpret them using the information in the <i>Data Booklet</i>. Learners create a check list of how to interpret these traces and then they could then use other spectra to practise all of these analytical skills. Provide worksheets for practising examples. To include: <ul style="list-style-type: none"> the meaning of δ values the meaning of peak areas interpretation of splitting patterns suggesting a structure. (I) Peer-marking of worksheets using mark scheme prepared by you. <p>http://www.rsc.org/learn-chemistry/resource/res00001340/chemistry-vignettes-nmr-theory</p>
KC1 22.5b	Predict the chemical shifts and splitting patterns of the protons in a given molecule.	<ul style="list-style-type: none"> You have several molecular models. Learners must: <ul style="list-style-type: none"> identify the number of ^1H environments suggest δ values predict splitting patterns.

Syllabus ref. and Key Concepts	Learning objectives	Suggested teaching activities
22.5c	Describe the use of tetramethylsilane, TMS, as the standard for chemical shift measurements.	<ul style="list-style-type: none"> Learners suggest the structure and formula of tetramethylsilane (TMS). You explain how it is used as a standard with $\delta=0$.
KC1 22.5d	State the need for deuterated solvents, e.g. CDCl_3 , when obtaining an NMR spectrum.	<ul style="list-style-type: none"> Learners work out the sub-atomic particles present in a deuterium atom You explain the need for a deuterated solvent.
KC1 22.5e	Describe the identification of O–H and N–H protons by proton exchange using D_2O .	<ul style="list-style-type: none"> You explain the use of D_2O to identify labile protons. Provide worksheets for practising examples. To include: <ul style="list-style-type: none"> the meaning of δ values the meaning of peak areas interpretation of splitting patterns suggesting a structure using D_2O the role of TMS the need for deuterated solvents. (I) Peer-marking of worksheets using mark scheme prepared by you.
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