CAMBRIDGE
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Cambridge
International
AS & A Level

Learner Guide

Cambridge International AS & A Level Chemistry

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Cambridge Advanced

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How to use this guide

The guide describes what you need to know about your GCE Advanced Subsidiary level (AS) or GCE Advanced Level (A) Chemistry examinations. Schools choose one of the three options for their learners:

- To take all Advanced Level components (AS and A2) in the same examination session leading to the full Advanced Level (A).
- To follow a staged assessment route to the Advanced Level (A) by taking the Advanced Subsidiary (AS) qualification in an earlier examination session. If you do well enough you then have to take the final part of the exam (A2) in a later examination session, leading to the full Advanced Level (A).
- To take the Advanced Subsidiary (AS) qualification only.

It is important when using this revision checklist that you know which one of the above three options has been chosen by your school, college or centre. If you do not know, then your chemistry teacher and examinations officer will know.

This guide will help you to plan your revision programme for the five Theory and Practical examination papers. It will explain what examiners are looking for in the answers you write. It can also be used to help you revise, by using ticks in Section 4 ('what you need to know') to check what you know and which topic areas you have covered.

The guide contains the following sections:

Section 1: How will you be tested?

This section will give you information about the different types of Theory and Practical examination papers that are available.

Section 2: Examination tips

This section gives you advice to help you do as well as you can. Some of the tips are general advice and some are based on the common mistakes that learners make in exams.

Section 3: What will be tested?

This section describes the areas of knowledge, understanding and skills that you will be tested on.

Section 4: What you need to know

This shows the syllabus content for AS and A2 in a simple way so that you can check:

- the topics you need to know about
- how the Theory differs from the Practical syllabus
- details about each topic in the syllabus
- how much of the syllabus you have covered

Section 1: How will you be tested?

1.1 The examination papers you will take

AS Level candidates enter for papers 1, 2 and 3

A2 candidates enter for papers 4 and 5

A Level candidates enter for papers 1, 2, 3, 4 and 5

1.2 Information about the examination papers

The table below gives you outline information about all the examination papers.

Paper	Type of paper	Duration	Marks	Weighting (%)	
				AS	A2
1	Multiple Choice	1 h	40	31%	15%
2	AS Structured Questions	1 h 15 min	60	46%	23%
3	Advanced Practical Skills	2 h	40	23%	12%
4	A2 Structured Questions	2 h	100		38%
5	Planning, Analysis and Evaluation	1 h 15 min	30		12%

1.3 Information about each examination paper

Paper 1 (1 hr) (40 marks)

40 multiple choice questions based on the AS core. The AS core consists of the parts of the syllabus sections 1 to 10 that are not in bold type. 30 items will be of the direct choice type and 10 of the multiple completion type. All questions will include 4 responses. You will write your answers on an answer grid provided. You will need to answer all the questions.

Paper 2 (1¼ hr) (60 marks)

A variable number of structured questions based on the AS core. You will write your answers on the question paper. You will need to answer all the questions.

Paper 3 Advanced Practical Skills (2 hr) (40 marks)

This will feature two or three experiments drawn from different areas of chemistry. The examiners will not be restricted by the subject content. The scope of the practical test is indicated in the Practical Chemistry Syllabus. You will write your answers on the question paper. You will need to answer all the questions.

Paper 4 (2 hr) (100 marks)

Section A is worth 70 marks and consists of questions based on the A2 core syllabus, but which may contain material from the AS syllabus. The A2 core consists of the parts of the syllabus sections 1 to 10 that are in bold type.

Section B is worth 30 marks and consists of questions based on the section "Applications of Chemistry", but which may contain material from the core AS and A2 syllabuses. The section "Applications of Chemistry" consists of the syllabus section 11.

You will write your answers on the question paper. You will need to answer all the questions.

Paper 5 Planning, Analysis and Evaluation (1¼ hr) (30 marks)

This paper will consist of a variable number of questions of variable mark value based on the practical skills of planning, analysis and evaluation. The examiners will not be restricted by the subject content. You will write your answers on the question paper. You will need to answer all the questions.

Section 2: Examination tips

How to use these tips

These tips highlight some common mistakes made by learners. They are collected under various subheadings to help you when you revise a particular topic.

General advice

- Read the question carefully. Yes, we know you've been told this before, but it is still a common issue. Misreading a question costs you marks if you could have answered the question that was there.
- Don't concentrate your revising on "difficult" material if it means you leave out the "easier" material. There will be many easier marks on each paper, so make sure you score them all. For example, learn all the definitions you have been taught, such as first ionisation energy and standard electrode potential.
- There will be harder questions on the paper. Some of these could involve elements or compounds you may not have studied. Don't give up on these questions! If you know your chemistry you will be able to score all the marks by *applying* what you know to these substances.
- Write clearly. If your answer to a question is "alkene" the person marking your papers must be able to be certain that you have written "alkene": if it looks at all like "alkane" you will not get the mark.
- Write numbers clearly. If your answer to a question is "0.46 moles" make sure the numbers are clear: if it looks like you might have written "0.96 moles" or "0.40 moles" you will not get the mark.
- If you have to make a correction, cross out what you have written and write down your new answer clearly in an available space. Don't try to write over the top of your previous answer, or fit the new answer into the space between lines of writing. Make sure you identify your new answer clearly, e.g. "continuation of Q4 (b)".
- On papers that give scope for longer answers, look at how many marks are available for each part of the question. For example, if part (a) has one mark and part (b) has two marks, then a single statement might be sufficient for part (a) but it won't be for part (b).
- In the example above, look out in part (b) for the possibility of writing a statement and an explanation.

General tips

- You are going to take several chemistry exam papers lasting a total of many hours. These papers will cover the whole syllabus very thoroughly. If you don't know something, don't gamble on it not coming up. Find it out and learn it. If this doesn't work go over it with your teacher and/or your classmates.
- Method marks contribute a lot to your total on many papers. Write out each step of your method! This is very important when you find you are unable to work all the way through a longer question to the final answer. Don't give up on it, or leave blanks. You may be able to score the majority of the marks. Examples of this situation include:
    - At the end of a four-mark calculation on gas volume you get an answer you know is wrong, e.g. you work out that 45,000 dm^3 of gas are released from a test tube reaction! If you write out your method in full you may still score three marks if you have only made one mistake. Even if you only score one mark it might be important.

  - You are answering a five-mark organic question in which you have to use information from the question to deduce the full structural formula of a compound. You find you cannot produce a structure that fits all the information. Answer the question anyway, stating in full what your deductions are from each separate piece of information in the question. Many answers like this can still score four or five marks, even without the final structure.

- Don't cross out an answer, or part of an answer, simply because you are unsatisfied with it. If you are changing an answer or part of an answer, only cross out your first answer if it contradicts your new answer. For example, a question asks "describe and explain the processes involved when sodium chloride dissolves in water":
  - you might start by writing "Sodium chloride is a covalent compound". If you then want to change this to "sodium chloride is an ionic compound", you must cross out your first answer because these two answers contradict each other.
  - alternatively, you might start by writing "Sodium chloride dissolves in water to give a solution of pH 7", and then you decide this is not relevant, and you need to start by considering the bonding in sodium chloride. Don't cross out your original statement. It may score you one or more marks.
- Round off calculations to the correct number of significant figures at the *end* of the calculation. Do not round off after each step of the calculation. If you do this, rounding errors can add together so that your final answer is not close enough to the correct answer.
- Be prepared to guess intelligently. For example, a question says that "when silver nitrate solution is added to an unknown solution a yellow precipitate forms". If you know that this means that either bromide or iodide ions are present, but you can't remember which, you have nothing to lose if you guess. If you leave the answer blank, you get no mark. If you guess wrongly, you get no mark. If you guess correctly, you score a mark.
- If a question asks you about an inorganic compound you are not familiar with, look at your periodic table. You may be able to answer the question by applying your knowledge of other elements in the same group. If, for example, you get a question about the shape or acid/base behaviour of phosphine (PH_3), think of what you know about ammonia (NH_3).
- If a question asks you about an organic compound you are not familiar with, look at the functional groups in the compound. You may be able to answer the question by applying your knowledge of how these functional groups behave. If, for example, you get a question about an organic compound with an aldehyde (-CHO) group, think of what you know about ethanal (CH_3CHO).

Paper 1: Multiple Choice

- Answer every question.
- If you are not sure about an answer, make a note of the question number on the front of your question paper. Go back to this question first if you have time at the end of the exam.
- Questions 1–30 have four answers. If you cannot spot the correct answer with certainty, mark each answer with a tick, a question mark, or a cross. Use this to decide which of the four answers is the best answer. Alternatively, if you do this and find that you still have to guess, you are more likely to get it right if you can eliminate one or two of the choices.
- Some questions will state a fact, and then ask for an explanation of the fact. Beware of answers that are true but do not answer the question, e.g. a question asks, "Why does water have a higher melting point than propanone?" and one of the four choices is: "water molecules are polar". This is true, but it does not answer the question as propanone molecules are also polar.
- Questions 31–40 have three statements. To answer these questions you have to decide whether each statement is true or not. When you have decided whether or not the first statement is true, put a tick

or cross by it. Do the same for the second and third statements. This way you don't have to remember your earlier decisions while looking at later statements.

- If a question involves a calculation write out your method. This will save you time if you have to check your answer.
- Any **bold type** in a question is there to draw your attention to something important.

Paper 2: AS Structured Questions

- Use the space on the paper as a rough guide to the length of answer necessary. If there are five lines to write in, a one-line answer is unlikely to be enough.
- You must learn definitions exactly, e.g. definitions of energy changes. Don't be satisfied with your learning of a definition until you are word perfect – you will lose marks otherwise.
- If state symbols are asked for in an equation, put them in. Read the question, and then answer it!
- Look out for questions that ask for an observation or statement *and* an explanation, and make sure you include the explanation. Look at the mark allocation to help you to decide how much detail is required in the explanation. There will probably be only one mark for the observation or statement.
- If a question asks for an explanation of a particular type you provide the answer that is being asked for. An example of this is a question that asks you to explain how the electronic configurations of the elements in a group affect the reactivity of the elements. If your answer concentrates on some other factor, for example the structure and bonding of the elements, it is unlikely to score marks.
- If you are calculating a $\Delta H^{\ominus}$ value in a thermochemistry question, don't forget that the $\Delta H^{\ominus}$ values you are given to work it out are *per mole* of substance. For example, if you are using $\Delta H^{\ominus}_f$ values to calculate the $\Delta H^{\ominus}$ of the decomposition $2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$ make sure you use <u>twice</u> the value of the $\Delta H^{\ominus}_f$ of $NaHCO_3$.
- Organic chemistry questions often ask for the isomers of a given compound to be drawn. Beware of writing answers that are simply redrawings of the same structure! You may find it easier here if you draw skeletal formulae as well as displayed formulae. It is often easier to spot two identical structures if they are drawn as skeletal formulae.
- Give answers that are as specific and as precise as you are able. For example, in an organic chemistry question worth two marks you have to name the functional groups in the compound $H_2C{=}CHCH_2CHO$. If you answer "The compound has a double bond and a carbonyl group" you will score no marks. Many compounds have double bonds, but if it is a C=C double bond then the specific name for the functional group is "alkene". Many compounds have carbonyl groups, but if the carbonyl group is directly bonded to a hydrogen atom then the specific name for the functional group is "aldehyde". If you answer "The compound has an alkene functional group and an aldehyde functional group" you will score two marks.
- Many questions will ask you to state the observations that will be made during an experiment. Make sure you use the accepted terms to describe colour changes that will be seen. Use examiners' reports and textbooks (e.g. *AS Level and A Level Chemistry* by Ratcliff et al) to find out what these accepted terms are, e.g. the colour change when acidified potassium dichromate solution is reduced should be described as "from orange to green". The colours of silver chloride, silver bromide and silver iodide should be described as white, cream and yellow respectively.

Paper 3: Advanced Practical Skills

- As with all exams it is essential that you read practical exam papers very carefully. You must follow the instructions on the paper so that you do the *correct* experiments and record the *correct* observations. If

the question tells you to record results or observations in a certain place you must record them in that place.

- Make sure you are well practised in handling all of the equations relating to titrations. Being able to convert between cm^3 and dm^3 is an essential part of this.
- Make sure you are well practised in the graphical techniques that have been necessary to answer questions on past papers. Get a set of results for each question of this sort and repeat the graphical exercises until your teacher agrees you have them right.
- Don't forget to record titration results in a suitable format, giving initial and final burette readings, and recording volumes to $0.05cm^3$, not $0.1cm^3$ or $0.01cm^3$.
- You need to get two titration results that are within $0.01cm^3$ of each other. You don't need more accurate results than this unless the question specifically says so.
- Have a mental checklist to use when titrating:
  - No air bubble in the tip of the burette
  - No air bubbles anywhere in the pipette
  - The bottom of the meniscus just touches the graduation on the pipette
  - The colour change you're looking for at the end-point should be caused by a single drop from the burette
- If a question tells you that repeated readings should not be taken, don't repeat the readings! There will be no marks given for the repeats, you may lose marks for failing to follow instructions, and you may run short of time.
- Make sure you are well practised in the correct vocabulary for recording observations, e.g. precipitate, slight, dense, soluble, insoluble, excess, gelatinous, and effervescence.
- If you are asked to record observations do so in as much detail as possible. If a solution is colourless, or a precipitate is white, say so. Don't just describe it as a "solution" or a "precipitate".
- If you have to add one solution to another, looking for observations, add it slowly. You need to notice the difference between an instant or sudden change and a gradual change.
- If a change is instant or sudden, say so. If a change is gradual, say so. If the change goes through intermediate stages, describe each of these stages.

Paper 4: A2 Structured Questions

- As with Paper 2 there will be definitions to learn for Paper 4. Make sure you know them exactly. Be strict with yourself when you are practising them.
- Some definitions will be essential in order to do calculations correctly. For example, you may have to do a calculation that involves C*l*-C*l* bonds. The data in the question says the bond energy for the C*l*-C*l* bond is +242 $kJmol^{-1}$. Does this energy value refer to making bonds or breaking them? Does this energy term refer to one mole of C*l*-C*l* bonds or one mole of C*l* atoms? If you don't know the definition of bond energy then you are unlikely to get the right answer to the question.
- If a question requires the use of data from the Data Booklet, write down the data you have selected. There may be a mark for choosing the correct data from the booklet.
- This paper will ask you to write balanced chemical equations. Practise this skill.
- If a question gives details of a reaction and asks you to explain it there will probably be a mark for a balanced chemical equation. Write an equation, including state symbols. This gives you extra chances to pick up marks.

  - There may be a mark for naming a certain product; if you forget to name it but write it in an equation you will get the mark.
  - There may be a mark for saying a gas is given off; if you forget to state this but write it in an equation with (g) after it you will get the mark.
  - There may be a mark for saying a precipitate forms; if you forget to state this but write it in an equation with (s) after it you may get the mark. For example, a question asks you about the thermal decomposition of the carbonates of Group 2 metals. If you write the equation $MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$ you will pick up any marks available for saying that the products include a metal oxide, or for saying that the products include carbon dioxide gas.

- Be definite and specific. If a question asks you to describe the structure and bonding of a substance you need to use two words. One word describes the structure – giant or simple. One word describes the bonding – metallic, ionic, or covalent. Your answer must be two words, chosen from this list of five.
- The organic questions on this paper often prove to be difficult! However you can make them much easier for yourself by learning all of the reactions the syllabus says you need to know. If you learn these reactions and practise writing the balanced chemical equations, you will give yourself the best chance you can.
- You are very likely to have to show your knowledge of at least one organic reaction mechanism. Practise them and make sure you know which reactions go by which mechanism. Learn the equations! Have a checklist in your memory for writing mechanisms:
  - Definitions – electrophile and nucleophile
  - Which bonds have to be labelled with dipoles ($\delta+$ and $\delta-$)
  - Curly arrows represent the movement of an electron pair, so the arrow should start on a lone pair, or a bond pair, or the delocalised electrons in a benzene ring, and the arrowhead should point towards the atom, ion or molecule that the electron pair is going to.
- **Applications of chemistry – Section B** *Questions based on these syllabus sections will often ask you to use your knowledge of core chemistry as well as your knowledge of the Applications Of Chemistry section of the syllabus.*
- The Chemistry of Life section is very factually based, you should learn this section thoroughly.
- The Applications of Analytical Chemistry section requires you to learn the skills to interpret mass spectra and NMR spectra. Practice these skills by answering as many sample questions as you can.
- The Design and Materials section does not contain a great deal of specified required knowledge. Identify the areas of knowledge involved – medicinal chemistry, polymers, and nanochemistry for example – and try to read about them in text books and on the internet. Look at the questions in past papers.
- If a question seems to be about an area of chemistry which you know little or nothing about, it is important not to panic.
- Let us suppose that a question seems to be in an area that is unfamiliar to you. The following is a strategy that you could use when tackling such questions.
  - Read carefully through the stem of the question and try to identify the areas of the course it is based on.
  - Think back to what you studied in this topic.
  - Look carefully at any information/data provided in the question.
  - Read each sub-question carefully and see how it links to what you know, and any of the data provided.
  - Remember these questions more often test your ability to apply what you know, not to recall specific points covered in lessons.
  - Remember – any data provided is there for a reason. You will need to use it, or to select from it, when answering one or more parts of the question.

Paper 5: Planning, Analysis and Evaluation

- The planning exercise will require you to define the problem and then describe a practical method.
- If you are asked to make a prediction, and to justify the prediction, make sure you do so.
- Your practical method should be detailed. Somebody else should be able to follow your method without having to come to you for clarification.
- Make sure any drawings of apparatus are done clearly and simply.
- If the results obtained will then have to be processed, explain how this will be done.
- The paper may include a data handling question.
- This will involve some simple maths. Check your maths, including the choice of the number of significant figures. If you are in doubt, work to 3 significant figures.
- You may have to plot a graph. Number and label the axes clearly. The labels should include the quantity (eg mass) and the units (eg g). The numbering of the axes should make plotting straightforward – if 0.1 g covers ten small squares then plotting is straightforward, if 0.25 g covers ten small squares then plotting is **less** straightforward – and the points to be plotted should use more than half the graph paper in each direction.
- You will have to evaluate an experiment and the set of results that was obtained.
- Identify any anomalous results, suggesting an explanation of how they arose.
- Consider the quality of the method.
- Comment on the apparatus chosen – was it suitable?
- You may be asked what conclusion can be drawn, and whether or not the data supports a given hypothesis.

Section 3: What will be tested?

3.1 Assessment objectives

We take account of the following in your answer papers.

Assessment objective:	What this examines:
A – **knowledge** *with* **understanding**	Remembering facts and applying these facts to new situations.
B – *ability in* **handling**, **applying** *and* **evaluating** *information*	How you extract information and rearrange it in a sensible pattern. How you carry out calculations and make predictions. You also need to reflect upon the validity and reliability of that information commenting on possible sources of error.
C – *use of* **experimental skills** *and* **investigations**	Planning and carrying out experiments and recording, analysing and evaluating information. You also need to reflect upon the validity and reliability of that information. You need to comment on possible sources of error and you need to identify ways in which to improve that experimental work.

3.2 Assessment objective details

The assessment objectives listed below reflect those parts of the aims of the course which will be assessed. This is a brief description and your teacher will be able to provide you with more detailed information on assessment objectives.

A. Knowledge with understanding

Demonstrate with relation to understanding:
scientific phenomena, facts, laws, definitions, concepts, theories
scientific vocabulary, terminology, conventions (including symbols, quantities and units)
scientific instruments and apparatus, including techniques of operation and aspects of safety
scientific quantities and their determination
scientific and technological applications with their social, economic and environmental implications
present reasoned explanations for phenomena, patterns and relationships

B. Handling, applying and evaluating information

You should be able (in words or by using symbolic, graphical and numerical forms of presentation) to:
locate, select, organise and present information from a variety of sources
handle information, distinguishing the relevant from the extraneous
manipulate numerical and other data and translate information from one form to another
analyse and evaluate information so as to identify patterns, report trends and draw inferences
construct arguments to support hypotheses or to justify a course of action
apply knowledge, including principles, to novel situations
evaluate information and hypotheses

C. Experimental skills and investigations

You should be able to:
plan investigations
use techniques, apparatus and materials
make and record observations, measurements and estimates
interpret and evaluate observations and experimental results
select techniques, apparatus and materials
evaluate methods and suggest possible improvements

3.3 Weighting of assessment objectives

This table gives a general idea of the allocation of marks to the assessment objectives, however the balance on individual papers may vary slightly from year to year.

Assessment Objective	Weighting (%)	On which papers?
A	46 (Approximately: Recall 27% and Understanding 19%)	1, 2 and 4
B	30	1, 2 and 4
C	24	3 and 5

3.4 Data Booklet

A Data Booklet is available for use in Papers 1, 2 and 4.

Section 4: What you need to know

4.1 Introduction

What you need to know is presented in a table, which describes the things you may be tested on in the examinations. These are arranged into themes, each being divided into topic areas. These topics are then subdivided into specific "things you should be able to do". These topics will be placed into one of two columns:

- **The first column is for learners studying AS and A2.**
- **The second column is *additional* material for learners studying A2.**

You need only refer to the first column (headed **learners studying AS and A2)** *if you are studying AS Level chemistry. If you are studying A Level chemistry then* ***both*** *columns are needed. If you are unsure about which material to use, you should ask your teacher for advice.*

4.2 How to use the table

You can use the table throughout your chemistry course to check the theme and topic areas you have covered. You can also use it as a revision aid. When you have a good knowledge of a topic, you tick the appropriate space in the checklist column.

The themes are:

Physical Chemistry: Atoms, molecules and stoichiometry
Physical Chemistry: Atomic structure
Physical Chemistry: Chemical bonding
Physical Chemistry: States of matter
Physical Chemistry: Chemical energetics
Physical Chemistry: Electrochemistry
Physical Chemistry: Equilibria
Physical Chemistry: Reaction kinetics
Inorganic Chemistry: The periodic table/chemical periodicity
Inorganic Chemistry: Group II
Inorganic Chemistry: Group IV
Inorganic Chemistry: Group VII
Inorganic Chemistry: An introduction to the chemistry of transition elements

Inorganic Chemistry: Nitrogen and sulfur
Organic Chemistry: Introductory topics
Organic Chemistry: Hydrocarbons
Organic Chemistry: Halogen derivatives
Organic Chemistry: Hydroxy compounds
Organic Chemistry: Carbonyl compounds
Organic Chemistry: Carboxylic acids and derivatives
Organic Chemistry: Nitrogen compounds
Organic Chemistry: Polymerisation
Practical syllabus.

4.3 Testing yourself

Test yourself as follows:

- cover up the details with a piece of paper
- try to remember the details
- when you have remembered the details correctly, put a tick in the appropriate space in the checklist column.

If you use a pencil to tick the space you can retest yourself whenever you want by simply rubbing out the ticks. If you are using the table to check the topics you have covered, you can put a tick in the topic column next to the appropriate bullet point.

The column headed **comments** *can be used:*

- to add further information about the details for each bullet point
- to note relevant page numbers from your text book
- to add learning aids e.g. OIL RIG (for oxidation is loss (of electrons) and reduction is gain (of electrons))
- to highlight areas of difficulty/things which you need to ask your teacher about.

Physical Chemistry: Atoms, molecules and stoichiometry

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
1	Atoms, molecules and stoichiometry	Relative masses of atoms and molecules	Define and use the terms relative atomic, isotopic, molecular and formula masses, based on the carbon-12 scale			
		The mole; the Avogadro constant	Define and use the term mole in terms of the Avogadro constant			
		The determination of relative atomic masses, A_r, and relative molecular masses, M_r, from mass spectra	Analysis of mass spectra in terms of isotopic abundances	Knowledge of the working of the mass spectrometer is not required	Analysis of mass spectra in terms of molecular fragments.	
			Calculate the relative atomic mass of an element given the relative abundances of its isotopes, or its mass spectrum			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
1	Atoms, molecules and stoichiometry	The calculation of empirical and molecular formulae	Define and use the terms empirical and molecular formulae	The term relative formula mass will be used for ionic compounds and relative molecular mass for covalent compounds		
			Calculate empirical and molecular formulae, using combustion data or composition by mass			
		Reacting masses and volumes (of solutions and gases)	Write and construct balanced equations			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
			Perform calculations, including use of the mole concept, involving: (i) reacting masses (from formulae and equations) (ii) volumes of gases (e.g. in the burning of hydrocarbons) (iii) volumes and concentrations of solutions	Work out answers to the number of significant figures asked for in the question. If a number of significant figures is not asked for then the number of significant figures in the least accurate piece of data should be used.		
			Deduce stoichiometric relationships from calculations			

Physical Chemistry: Atomic structure

Syllabus section	Theme	Topic	Learners studying AS and A2		***Additional*** material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
2	Atomic structure	The nucleus of the atom: neutrons and protons, isotopes, proton and nucleon numbers	Identify and describe protons, neutrons and electrons in terms of their relative charges and relative masses			
			Deduce the behaviour of beams of protons, neutrons and electrons in electric fields			
			Describe the distribution of mass and charges within an atom			
			Deduce the numbers of protons, neutrons and electrons present in both atoms and ions given proton and nucleon numbers and charge			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
			Describe the contribution of protons and neutrons to atomic nuclei in terms of proton number and nucleon number			
			Distinguish between isotopes on the basis of different numbers of neutrons present			
		Electrons: electronic energy levels, ionisation energies, atomic orbitals, extranuclear structure	Describe the number and relative energies of the s, p and d orbitals for the principal quantum numbers 1, 2 and 3 and also the 4s and 4p orbitals			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
2	Atomic structure		Describe the shapes of s and p orbitals		Describe the shapes of d orbitals	
			Use $1s^2 2s^2 2p^6$etc notation to state the electronic configuration of atoms and ions given the proton number and charge			
			Explain and use the term ionisation energy		Explain and use the term electron affinity	
			Explain the factors influencing the ionisation energies of elements			
			Explain the trends in ionisation energies across a period and down a group of the Periodic Table			
			Deduce the electronic configurations of elements from successive ionisation energy data			
			Interpret successive ionisation energy data of an element in terms of the position of that element within the Periodic Table			

Physical Chemistry: Chemical Bonding

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
3	Chemical bonding	Ionic (electrovalent) bonding	Describe ionic (electrovalent) bonding, as in sodium chloride and magnesium oxide, including the use of 'dot-and-cross' diagrams			
		Covalent bonding and co-ordinate (dative covalent) bonding	Describe, including the use of 'dot-and-cross' diagrams, covalent bonding. For example as in hydrogen, oxygen, chlorine, hydrogen chloride, carbon dioxide, methane and ethene			
			Describe, including the use of 'dot-and-cross' diagrams, co-ordinate (dative covalent) bonding. For example as in the formation of the ammonium ion and in the Al_2Cl_6 molecule			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
			Explain the shapes of and bond angles in molecules by using the qualitative model of electron-pair repulsion (including lone pairs). Use simple examples such as: BF_3 (trigonal); CO_2 (linear); CH_4 (tetrahedral); NH_3 (pyramidal); H_2O (non-linear); SF_6 (octahedral): PF_5 (trigonal bipyramidal) to illustrate your answers			
			Describe covalent bonding in terms of orbital overlap, giving σ and π bonds			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do		Things you should be able to do	Comment
3	Chemical bonding		Describe the concept of hybridisation to form sp, sp^2, and sp^3 orbitals			
			Explain the shape of, and bond angles in, the ethane and ethene molecules in terms of σ and π bonds		Explain the shape of, and bond angles in benzene molecules in terms of σ and π bonds	
			Predict the shapes of and bond angles in molecules similar to those stated above			
		Covalent bonding: bond energies, bond lengths and bond polarities	Explain the terms bond energy, bond length and bond polarity and use them to compare the reactivities of covalent bonds			
			Show understanding of chemical reactions in terms of energy transfers associated with the breaking and making of chemical bonds			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do		Things you should be able to do	Comment
		Intermolecular forces, including hydrogen bonding	Describe hydrogen bonding, using ammonia and water as simple examples of molecules containing N-H and O-H groups			
			Describe intermolecular forces (van der Waals' forces), based on permanent and induced dipoles, as in $CHCl_3$(l); Br_2(l) and the liquid noble gases			
			Apply the concept of electronegativity to explain bond polarity, dipole moments, the behaviour of oxides with water, the acidities of chlorine-substituted ethanoic acids			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
3	Chemical bonding	Metallic bonding	Describe metallic bonding in terms of a lattice of positive ions surrounded by mobile electrons			
		Bonding and physical properties	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			
			Deduce the type of bonding present from given information			

Physical Chemistry: States of Matter

Syllabus section	Theme	Topic	Learners studying AS and A2		***Additional*** **material for learners studying A2**	
			Things you should be able to do	**Comment**	**Things you should be able to do**	**Comment**
4	States of matter	The gaseous state: ideal gas behaviour and deviations from it	State the basic assumptions of the kinetic theory as applied to an ideal gas			
			Explain qualitatively in terms of intermolecular forces and molecular size the conditions necessary for a gas to approach ideal behaviour			
			Explain qualitatively in terms of intermolecular forces and molecular size the limitations of ideality at very high pressures and very low temperatures			
		The gaseous state: $pV = nRT$ and its use in determining a value for M_r	State and use the general gas equation $pV = nRT$ in calculations, including the determination of M_r			
		The liquid state: the kinetic concept of the liquid state and simple kinetic-molecular descriptions of changes of state	Describe, using a kinetic-molecular model, the liquid state; melting; vaporisation and vapour pressure			

Syllabus Section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
4	States of matter	The solid state: lattice structures	Describe, in simple terms, the lattice structure of a crystalline solid which is: (i) ionic, as in sodium chloride, magnesium oxide (ii) simple molecular, as in iodine (iii) giant molecular, as in graphite; diamond; silicon(IV) oxide (iv) hydrogen-bonded, as in ice (v) metallic, as in copper	The concept of the 'unit cell' is not required		
			Explain the strength, high melting point, electrical insulating properties of ceramics in terms of their giant molecular structure			
			Relate the uses of ceramics, based on magnesium oxide, aluminium oxide and silicon(IV) oxide, to their properties (suitable examples include furnace linings; electrical insulators; glass; crockery)			

Syllabus Section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
			Discuss the finite nature of materials as resources and the importance of recycling processes			
			Outline the importance of hydrogen bonding to the physical properties of substances, including ice and water			
			Suggest from quoted physical data the type of structure and bonding present in a substance			

Physical Chemistry: Chemical Energetics

Syllabus Section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
5	Chemical energetics	Enthalpy changes	Explain that chemical reactions are accompanied by energy changes, principally in the form of heat energy; the energy changes can be exothermic (ΔH negative) or endothermic (ΔH positive)			
			Explain and use the terms: enthalpy change of reaction and standard conditions, with particular reference to: formation; combustion; hydration; solution; neutralisation; atomisation			
			Explain and use the terms: bond energy (ΔH positive, i.e. bond breaking)		Explain and use the terms: lattice energy (ΔH negative, i.e. gaseous ions to solid lattice)	
			Calculate enthalpy changes from appropriate experimental results, including the use of the relationship enthalpy change = $mc\Delta T$		Explain, in qualitative terms, the effect of ionic charge and of ionic radius on the numerical magnitude of a lattice energy	
			Construct and interpret a reaction pathway diagram, in terms of the enthalpy change of the reaction and of the activation energy			

Syllabus Section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
5	Chemical energetics	Hess' Law, including Born-Haber cycles	Apply Hess' Law to construct simple energy cycles, and carry out calculations involving such cycles and relevant energy terms, with particular reference to determining enthalpy changes that cannot be found by direct experiment, e.g. an enthalpy change of formation from enthalpy changes of combustion		Apply Hess' Law to construct simple energy cycles, and carry out calculations involving such cycles and relevant energy terms, with particular reference to the formation of a simple ionic solid and of its aqueous solution	
			Apply Hess' Law to construct simple energy cycles, and carry out calculations involving such cycles and relevant energy terms, with particular reference to average bond energies		Apply Hess' Law to construct simple energy cycles, and carry out calculations involving such cycles and relevant energy terms, with particular reference to Born-Haber cycles (including ionisation energy and electron affinity)	

Physical Chemistry: Electrochemistry

Syllabus Section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
6	Electrochemistry	Redox processes and oxidation numbers	Calculate oxidation numbers of elements in compounds and ions			
			Describe and explain redox processes in terms of electron transfer and/or of changes in oxidation number (oxidation state)			
			Use changes in oxidation numbers to help balance chemical equations.			
		Industrial processes	Explain, including the electrode reactions, the industrial processes of: (i) the electrolysis of brine, using a diaphragm cell (ii) the extraction of aluminium from molten aluminium oxide/cryolite (iii) the electrolytic purification of copper			

Syllabus Section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
		Electrode potentials			Define the terms: (i) standard electrode (redox) potential (ii) standard cell potential	
					Describe the standard hydrogen electrode	
					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	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
6	Electrochemistry	Electrode potentials			Calculate a standard cell potential by combining two standard electrode potentials	
					Use standard cell potentials to explain/deduce the direction of electron flow from a simple cell	
					Use standard cell potentials to predict the feasibility of a reaction	
					Construct redox equations using the relevant half-equations	
					Predict qualitatively how the value of an electrode potential varies with the concentration of the aqueous ion	
		Batteries and fuel cells			State the possible advantages of developing other types of cell, e.g. the H_2/O_2 fuel cell and improved batteries (as in electric vehicles) in terms of smaller size, lower mass and higher voltage	

Syllabus section	Theme	Topic	Learners studying AS and A2		***Additional*** **material for learners studying A2**	
			Things you should be able to do	**Comment**	**Things you should be able to do**	**Comment**
		Electrolysis: factors affecting the substance and the amount of that substance liberated during electrolysis			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	
		Electrolysis: the Faraday constant, the Avogadro constant and their relationship			State the relationship, F = Le, between the Faraday constant, the Avogadro constant and the charge on the electron	
					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 H_2SO_4(aq); Na_2SO_4(aq)	
					Describe the determination of a value of the Avogadro constant by an electrolytic method	

Physical Chemistry: Equilibria

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
7	Equilibria	Reversible reactions	Explain, in terms of rates of the forward and reverse reactions, what is meant by a reversible reaction			
		Dynamic equilibrium	Explain, in terms of rates of the forward and reverse reactions, what is meant by a dynamic equilibrium			
		Factors affecting chemical equilibria	State Le Chatelier's Principle and apply it to deduce the qualitative effects of changes in temperature, concentration or pressure, on a system at equilibrium			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
			State whether changes in concentration, pressure, temperature or the presence of a catalyst, affect the value of the equilibrium constant for a reaction			
		Equilibrium constants	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		
			Calculate the values of equilibrium constants in terms of concentrations or partial pressures from appropriate data			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
7	Equilibria		Calculate the quantities present at equilibrium, given appropriate data	Such calculations will not require the solving of quadratic equations		
		The Haber process	Describe and explain the conditions used in the Haber process			
		The Contact process	Describe and explain the conditions used in the Contact process			
		Bronsted-Lowry theory of acids and bases	Show understanding of, and use, the Bronsted-Lowry theory of acids and bases, including the use of the acid-I, base-II concept			
		Acid dissociation constants, K_a and pK_a	Explain qualitatively the differences in behaviour between strong and weak acids and bases in terms of the extent of dissociation		Explain the terms pH, K_a, pK_a and use in calculations	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
					Calculate [H+(aq)] and pH values for strong and weak acids and strong bases	
		The ionic product of water, K_w			Explain the term K_w and use in calculations	
		pH: choice of pH indicators			Explain the choice of suitable indicators for acid-base titrations, given appropriate data	
					Describe the changes in pH during acid-base titrations and explain these changes in terms of the strengths of the acids and bases	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
7	Equilibria	Buffer solutions			Explain how buffer solutions control pH	
					Describe and explain their uses, including the role of HCO_3^- ion in controlling pH in blood	
					Calculate the pH of buffer solutions, given appropriate data	
		Solubility product			Show understanding of, and use, the concept of solubility product, K_{sp}	
					Calculate K_{sp} from concentrations and vice versa	
		The common ion effect			Show understanding of the common ion effect	

Physical Chemistry: Reaction kinetics

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
8	Reaction kinetics	Terminology	Explain and use the terms: rate of reaction; activation energy; catalysis		Explain and use the terms: rate equation; order of reaction; rate constant; half-life of a reaction; rate-determining step	
		Collision theory and Boltzmann distribution	Explain qualitatively, in terms of collisions, the effect of concentration changes on the rate of a reaction			
			Show understanding of the term activation energy, including reference to the Boltzmann distribution			
			Explain qualitatively, in terms of the Boltzmann distribution and the collision frequency, the effect of temperature change on the rate of a reaction			
		Catalysis	Explain that, in the presence of a catalyst, a reaction has a different mechanism, i.e. one of lower activation energy			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
8	Reaction kinetics		Interpret this catalytic effect in terms of the Boltzmann distribution			
			Describe enzymes as biological catalysts (proteins) which usually have very specific activity			
		Rate equations			Construct and use rate equations of the form rate = $k[A]^m[B]^n$	Limited to simple cases of single step reactions and multi-step processes with a rate-determining step for which *m* and *n* are 0, 1 or 2
		Order of reaction			Deduce the order of a reaction by the initial rates method	
					Deduce the order of a reaction by the half-life method	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
					Deduce, for zero- and first-order reactions, the order of reaction from concentration-time graphs	
					Verify that a suggested reaction mechanism is consistent with the observed kinetics	
					Predict the order that would result from a given reaction mechanism (and vice versa)	
					Calculate an initial rate using concentration data	Integrated forms of rate are not required
					Show understanding that the half-life of a first-order reaction is independent of concentration	
					Use the half-life of a first-order reaction in calculations	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
8	Reaction kinetics	Rate constant			Calculate a rate constant using the initial rates method	
					Calculate a rate constant using the half-life method	
					Devise a suitable experimental technique for studying the rate of a reaction, from given information	
		Modes of action in homogeneous and heterogeneous catalysis			The catalytic role of iron in the Haber process	
					The catalytic removal of oxides of nitrogen in the exhaust gases from car engines	
					The catalytic role of atmospheric oxides of nitrogen in the oxidation of atmospheric sulfur dioxide	
					The catalytic role of Fe^{3+} in the I^- / $S_2O_8^{2-}$ reaction	

Inorganic Chemistry: The Periodic Table/Chemical Periodicity

Syllabus section	Theme	Topic	Learners studying AS and A2		***Additional*** **material for learners studying A2**	
			Things you should be able to do	**Comment**	**Things you should be able to do**	**Comment**
9.1	The periodic table/ chemical periodicity	Periodicity of physical properties of the elements across the third period (sodium to argon)	Describe qualitatively (and indicate the periodicity in) the variations in atomic radius, ionic radius, melting point and electrical conductivity of the elements (see the *Data Booklet*)			
			Explain qualitatively the variation in atomic radius and ionic radius			
			Interpret the variation in melting point and in electrical conductivity in terms of the presence of simple molecular, giant molecular or metallic bonding in the elements			
			Explain the variation in first ionisation energy			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
		Periodicity of chemical properties of the elements in the third period	Describe the reactions, if any, of the elements with oxygen to give Na_2O; MgO; Al_2O_3; P_4O_{10}; SO_2; SO_3			
			Describe the reactions, if any, of the elements with chlorine to give NaCl; $MgCl_2$; Al_2Cl_6; $SiCl_4$; PCl_5			
			Describe the reactions, if any, of the elements Na and Mg only with water			
			State and explain the variation in oxidation number of the oxides and chlorides			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
9.1	The periodic table/ chemical periodicity		Describe the reactions of the oxides with water	Treatment of peroxides and superoxides is not required		
			Describe and explain the acid/base behaviour of oxides and hydroxides, including, where relevant, amphoteric behaviour in reaction with sodium hydroxide (only) and acids			
			Describe and explain the reactions of the chlorides with water			
			Interpret the variations and trends in chemical properties in terms of bonding and electronegativity			
			Suggest the types of chemical bonding present in chlorides and oxides from observations of their chemical and physical properties			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
			Predict the characteristic properties of an element in a given group by using knowledge of chemical periodicity			
			Deduce the nature, possible position in the Periodic Table, and identity of unknown elements from given information of physical and chemical properties			

Inorganic Chemistry: Group II

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
9.2	Group II	Similarities and trends in the properties of the Group II metals and their compounds	Describe the reactions of the elements with: oxygen, water and dilute acids			
			Describe the behaviour of the oxides, hydroxides and carbonates with water and with dilute acids			
			Describe the thermal decomposition of the nitrates and carbonates		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 the polarisability of the large anion	
			Interpret and make predictions from the trends in physical and chemical properties of the elements and their compounds			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
					Interpret and explain qualitatively the variation in solubility of the sulfates in terms of relative magnitudes of the enthalpy change of hydration and the corresponding lattice energy	
		Uses of Group II compounds	Explain the use of magnesium oxide as a refractory lining material			
			Describe and explain the use of lime in agriculture			

Inorganic Chemistry: Group IV

Syllabus section	Theme	Topic	Learners studying AS and A2		***Additional*** **material for learners studying A2**	
			Things you should be able to do	**Comment**	**Things you should be able to do**	**Comment**
9.3	Group IV	General properties			Understand that the elements (carbon to lead) and their compounds change their physical and chemical properties with increasing proton number from non-metals through metalloids to metals	
		The variation in melting points and electrical conductivities			Outline the variation in melting point and in electrical conductivity of the elements and interpret them in terms of structure and bonding	
		The bonding, molecular shape, volatility and hydrolysis of the tetrachlorides			Describe and explain the bonding in, molecular shape and volatility of the tetrachlorides	
					Describe and explain the reactions of the tetrachlorides with water in terms of structure and bonding	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
		The bonding, acid/base nature and thermal stability of the oxides			Describe and explain the bonding, acid-base nature and thermal stability of the oxides of oxidation states II and IV	
		The relative stability of higher and lower oxidation states			Describe and explain the relative stability of higher and lower oxidation states of the elements in their oxides and aqueous cations, including where relevant $E^{\ominus}$ values	

Inorganic Chemistry: Group VII

Syllabus section	Theme	Topic	Learners studying AS and A2		***Additional*** **material for learners studying A2**	
			Things you should be able to do	**Comment**	**Things you should be able to do**	**Comment**
9.4	Group VII	Characteristic physical properties	Describe the colours of chlorine, bromine and iodine			
			Describe the trend in volatility of chlorine, bromine and iodine			
			Interpret the volatility of the elements chlorine, bromine and iodine, in terms of van der Waals' forces			
		The relative reactivity of the elements as oxidising agents	Describe the relative reactivity of the elements chlorine, bromine and iodine as oxidising agents		Deduce from $E^{\ominus}$ values the relative reactivity of the elements chlorine, bromine and iodine, as oxidising agents	
			Describe and explain the reactions of the elements with hydrogen			
			Describe and explain the relative thermal stabilities of the hydrides.			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
			Interpret these relative stabilities in terms of bond energies			
		Some reactions of the halide ions	Describe and explain the reactions of halide ions with aqueous silver ions followed by aqueous ammonia			
			Describe and explain the reactions of halide ions with concentrated sulfuric acid			
		The manufacture of chlorine	Outline a method for the manufacture of chlorine from brine by a diaphragm cell			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
9.4	Group VII	The reactions of chlorine with aqueous sodium hydroxide	Describe and interpret in terms of changes of oxidation number the reaction of chlorine with cold, and with hot, aqueous sodium hydroxide			
			Explain the use of chlorine in water purification			
			State the industrial importance and environmental significance of the halogens and their compounds, including: bleach, PVC, halogenated hydrocarbons as solvents, as refrigerants, and in aerosols.			

Inorganic Chemistry: An introduction to the chemistry of transition elements

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
9.5	An introduction to the chemistry of transition elements	General physical and chemical properties of the elements (titanium to copper) and their compounds	State examples of catalysis by transition metals and their compounds			
					Explain the meaning of *transition element*, in terms of d-block elements forming one or more stable ions with incomplete d orbitals	
					State the electronic configuration of the first row transition elements and of their ions	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
					Contrast, qualitatively, the melting point; density; atomic radius; ionic radius; first ionisation energy and conductivity of the transition elements with calcium as a typical s-block element	
					Describe the tendency of transition elements to have variable oxidation states	
					Predict from a given electronic configuration, the likely oxidation states of a transition element	
					Describe and explain the use of Fe^{3+}/Fe^{2+}, MnO_4^-/Mn^{2+} and $Cr_2O_7^{2-}/Cr^{3+}$ as examples of redox systems	

Syllabus section	Theme	Topic	Learners studying AS and A2		***Additional*** **material for learners studying A2**	
			Things you should be able to do	**Comment**	**Things you should be able to do**	**Comment**
9.5	An introduction to the chemistry of transition elements				Predict, using $E^{\ominus}$ values, the likelihood of redox reactions	
		Colour of complexes			Explain the reactions of transition elements with ligands to form complexes, including the complexes of copper(II) ions with water, hydroxide, ammonia and chloride ions	
					Define a *ligand* as a species that has a lone pair and can form a dative bond to a central metal atom or ion.	
					Define a *complex* as a molecule or ion formed by a central metal atom or ion surrounded by one or more ligands.	
					Describe transition metal complexes as linear, octahedral, tetrahedral, or square planar	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
9.5	An introduction to the chemistry of transition elements				Explain qualitatively that ligand exchange may occur including the complexes of copper(II) ions with water, hydroxide, ammonia and chloride ions	
					Describe the shape and symmetry of d orbitals	
					Describe the splitting of degenerate d orbitals into two energy levels in octahedral complexes eg copper(II) ions with water and ammonia	
					Explain the origin of colour in transition element complexes (light energy absorbed in d-d transitions)	
					Describe qualitatively the effect of different ligands on absorption and therefore colour: eg copper(II) ions with water, hydroxide, ammonia and chloride ligands	
					Apply these ideas of ligands and complexes to other metals, given information.	

Inorganic Chemistry: Nitrogen and Sulfur

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
9.6	Nitrogen and sulfur	Nitrogen: Its unreactivity	Explain the lack of reactivity of nitrogen			
		Ammonia, ammonium ion, nitric acid and fertilisers	Describe and explain the basicity of ammonia			
			Describe and explain the formation (by an acid-base reaction) and the structure of the ammonium ion			
			Describe the displacement of ammonia from its salts			
			Describe the Haber process for the manufacture of ammonia from its elements, giving essential operating conditions, and interpret these conditions (qualitatively) in terms of the principles of kinetics and equilibria			
			State the industrial importance of ammonia and nitrogen compounds derived from ammonia			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
9.6	Nitrogen and sulfur	Nitrogen: The environmental impact of nitrogen oxides and nitrates	State and explain the environmental consequences of the uncontrolled use of nitrate fertilisers			
			State and explain the natural and man-made occurrence of oxides of nitrogen			
			State and explain the catalytic removal of oxides of nitrogen from car exhaust gases			
			Explain why atmospheric oxides of nitrogen are pollutants, including their catalytic role in the oxidation of atmospheric sulfur dioxide			
		Sulfur: The formation of atmospheric sulfur dioxide and the use of sulfur dioxide in food preservation	Describe the formation of atmospheric sulfur dioxide from the combustion of sulfur contaminated carbonaceous fuels			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
			State the role of sulfur dioxide in the formation of acid rain and describe the main environmental consequences of acid rain			
			Describe the use of sulfur dioxide in food preservation			
		Sulfur: Sulfuric acid	State the main details of the Contact process for sulfuric acid production			

Organic Chemistry: Introductory topics

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
Although there are features of organic chemistry topics that are distinctive, it is intended that you make cross-references with other themes/ topics in the syllabus. When describing preparative reactions, you will be expected to quote the reagents, e.g. aqueous NaOH, the essential practical conditions, e.g. reflux, and the identity of each of the major products. Detailed knowledge of practical procedures are not required: however, you may be expected to suggest (from your knowledge of the reagents, essential conditions and products) what steps may be needed to purify / extract a required product from the reaction mixture. In equations for organic redox reactions, the symbols [O] and [H] are acceptable. In each of the sections below, 10.1 to 10.8, you will be expected to be able to predict the reaction products of a given compound in reactions that are chemically similar to those specified.						

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
10.1	Introductory topics	Molecular, structural and empirical formulae	Write structural formulae e.g. $CH_3CH_2CH_2OH$ for propan-1-ol and not C_3H_7OH.			
			Write displayed formulae showing the relative placing of all atoms and the number of bonds between all the atoms	Knowledge of benzene or its compounds is not required for AS The circle-in-a-hexagon convention for representing the aromatic ring is preferred The hexagon symbol for cyclohexane is acceptable		
			Draw optical isomers giving three-dimensional structures according to the convention used			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
10.1	Introductory topics	Functional groups and the naming of organic compounds	Interpret and use the general, structural, displayed and skeletal formulae of alkanes and alkenes		Interpret and use the general, structural, displayed and skeletal formulae of arenes	You will be expected to recognise the shape of the benzene ring
			Interpret and use the general, structural, displayed and skeletal formulae of halogenoalkanes		Interpret and use the general, structural, displayed and skeletal formulae halogenoarenes	
			Interpret and use the general, structural, displayed and skeletal formulae of alcohols (including primary, secondary and tertiary)		Interpret, and use the general, structural, displayed and skeletal formulae of phenols	
			Interpret and use the general, structural, displayed and skeletal formulae of aldehydes and ketones			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
			Interpret and use the general, structural, displayed and skeletal formulae of carboxylic acids and esters		Interpret and use the general, structural, displayed and skeletal formulae of acyl chlorides	
			Interpret and use the general, structural, displayed and skeletal formulae of amines (primary only) and nitriles		Interpret and use the general, structural, displayed and skeletal formulae of amides and amino acids	
		Characteristic organic reactions	Interpret and use the term: functional group			
			Interpret and use the terms: homolytic and heterolytic fission, free radical, initiation, propagation and termination			
			Interpret and use the terms: nucleophile, electrophile, addition, substitution, elimination and hydrolysis			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
10.1	Introductory topics		Interpret and use the terms: oxidation and reduction	In equations for organic redox reactions, the symbols [O] and [H] are acceptable		
		Shapes of organic molecules; σ and π bonds	Describe the shapes of the ethane and ethene molecules		Describe the shape of the benzene molecule	
			Predict the shapes of other related molecules			
			Explain the shapes of the ethane and ethene molecules in terms of σ and π carbon-carbon bonds		Explain the shape of the benzene molecule in terms of σ and π carbon-carbon bonds	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
		Isomerism: structural; cis-trans; optical	Describe structural isomerism and its division into chain, positional, and functional group isomerism			
			Describe stereoisomerism and its division into geometrical (cis-trans) and optical isomerism			
			Describe cis-trans isomerism in alkenes, and explain its origin in terms of restricted rotation due to the presence of π bonds			
			Explain what is meant by a chiral centre and that such a centre gives rise to optical isomerism			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
10.1	Introductory topics		Deduce the possible isomers for an organic molecule of known molecular formula			
			Identify chiral centres and/or cis-trans isomerism in a molecule of given structural formula			
			Deduce the molecular formula of a compound from its structural, displayed, or skeletal formula.			

Organic Chemistry: Hydrocarbons

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
10.2	Hydrocarbons	Alkanes	Be aware of the general unreactivity of alkanes, including towards polar reagents	Exemplified by ethane		
			Describe the chemistry of alkanes: combustion, substitution by chlorine and substitution by bromine			
			Describe the mechanism of free-radical substitution at methyl groups with particular reference to the initiation, propagation and termination reactions			
		Alkenes	Describe the chemistry of alkenes: addition of hydrogen, steam, hydrogen halides and halogens	Exemplified by ethene		

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
			Describe Markovnikov addition of asymmetric electrophiles to propene			
			Describe the chemistry of alkenes: oxidation by cold, dilute MnO_4^- to form the diol			
			Describe the chemistry of alkenes: oxidation by hot, concentrated MnO_4^- rupturing the carbon-to-carbon double bond, determining the position of C=C in larger molecules			
			Describe the chemistry of alkenes: polymerisation			
			Describe the mechanism of electrophilic addition in alkenes, using bromine/ethene and HBr/propene as examples			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
10.2	Hydrocarbons	Arenes			Describe the chemistry of arenes: substitution reactions with chlorine and with bromine	Exemplified by benzene and methylbenzene
					Describe the chemistry of arenes: nitration	
					Describe the chemistry of arenes: oxidation of the side-chain to give a benzoic acid	
					Describe the mechanism of electrophilic substitution in arenes, using the mononitration and bromination of benzene as examples	
					Suggest the mechanism of other electrophilic substitution reactions, given data.	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
					Describe the effect of the delocalisation of electrons in the electrophilic substitution in arenes	
					Predict whether halogenation will occur in the side-chain or aromatic nucleus in arenes depending on reaction conditions	
					Apply the knowledge of positions of substitution in the electrophilic substitution of arenes	
		Hydrocarbons as fuels	Explain the use of crude oil as a source of aliphatic and aromatic hydrocarbons			
			Suggest how 'cracking' can be used to obtain more useful alkanes and alkenes of lower M_r from larger hydrocarbon molecules			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
10.2	Hydrocarbons		Describe and explain how the combustion reactions of alkanes led to their use as fuels in the home, industry and transport			
			Recognise the environmental consequences of carbon monoxide, oxides of nitrogen and unburnt hydrocarbons arising from the internal combustion engine			
			Recognise the environmental consequences of the catalytic removal of pollutant gases			
			Recognise the environmental consequences of gases that contribute to the enhanced greenhouse effect			

Organic Chemistry: Halogen derivatives

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
10.3	Halogen derivatives	Halogenoalkanes and halogenoarenes	Recall the chemistry of halogenoalkanes as exemplified by the following nucleophilic substitution reactions of bromoethane: hydrolysis; formation of nitriles; formation of primary amines by reaction with ammonia			
			Recall the chemistry of halogenoalkanes as exemplified by the elimination of hydrogen bromide from 2-bromopropane			
			Describe the mechanism of nucleophilic substitution in halogenoalkanes			
			Describe S_N1 and S_N2 mechanisms			

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
		Relative strength of the C-Hal bond	Interpret the different reactivities of halogenoalkanes with particular reference to hydrolysis and the relative strengths of C-Hal bonds		Interpret the different reactivities of halogenoalkanes and chlorobenzene with particular reference to hydrolysis and the relative strengths of C-Hal bonds.	
			Explain the uses of fluoroalkanes and fluorohalogenoalkanes in terms of their relative chemical inertness			
			Recognise the concern about the effect of chlorofluoroalkanes on the ozone layer			

Organic Chemistry: Hydroxy compounds

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
10.4	Hydroxy compounds	Alcohols	Recall the chemistry of alcohols, exemplified by ethanol: combustion	(exemplified by ethanol)		
			Recall the chemistry of alcohols, exemplified by ethanol: substitution to give halogenoalkanes			
			Recall the chemistry of alcohols, exemplified by ethanol: reaction with sodium			
			Recall the chemistry of alcohols, exemplified by ethanol: oxidation to carbonyl compounds and carboxylic acids			
			Recall the chemistry of alcohols, exemplified by ethanol: dehydration to alkenes			
			Recall the chemistry of alcohols, exemplified by ethanol: ester formation		Recall the chemistry of alcohols, exemplified by ethanol: acylation with acyl chlorides	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
			Classify hydroxy compounds into primary, secondary and tertiary alcohols			
			Suggest characteristic distinguishing reactions, e.g. mild oxidation			
					Deduce the presence of a $CH_3CH(OH)$- group in an alcohol from its reaction with alkaline aqueous iodine to form tri-iodomethane	
		Phenol			Recall the chemistry of phenol, as exemplified by the reaction with bases	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
10.4	Hydroxy compounds				Recall the chemistry of phenol, as exemplified by the reaction with sodium	
					Recall the chemistry of phenol, as exemplified by the nitration of and bromination of the aromatic ring	
					Recall the chemistry of phenol, as exemplified by the reaction with diazonium salts	
					Explain the relative acidities of water, phenol and ethanol	

Organic Chemistry: Carbonyl compounds

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
10.5	Carbonyl compounds	Aldehydes Ketones	Describe the formation of aldehydes and ketones from primary and secondary alcohols respectively using $Cr_2O_7^{2-}/H^+$	Aldehydes exemplified by ethanal, ketones exemplified by propanone		Ketones exemplified by phenylethanone
			Describe the reduction of aldehydes and ketones using $NaBH_4$ or $LiAlH_4$			
			Describe the mechanism of the nucleophilic addition reactions of hydrogen cyanide with aldehydes and ketones			
			Describe the use of 2,4-dinitrophenylhydrazine reagent (2,4-DNPH) to detect the presence of carbonyl compounds			
			Deduce the nature (aldehyde or ketone) of an unknown carbonyl compound from the results of simple tests (i.e. Fehling's and Tollens' reagents; ease of oxidation)			

Syllabus section	Theme	Topic	Learners studying AS and A2		***Additional*** **material for learners studying A2**	
			Things you should be able to do	**Comment**	**Things you should be able to do**	**Comment**
					Describe the reaction of CH_3CO^- compounds with alkaline aqueous iodine to give tri-iodomethane	

Organic Chemistry: Carboxylic acids and derivatives

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	**Comment**	**Things you should be able to do**	**Comment**
10.6	Carboxylic acids and derivatives	Carboxylic acids	Describe the formation of carboxylic acids from alcohols, aldehydes and nitriles	Exemplified by ethanoic acid		Exemplified by benzoic acid
			Describe the reactions of carboxylic acids in the formation of salts, using reactive metals, alkalis, or carbonates		Describe the reactions of carboxylic acids in the formation of acyl chlorides	
			Describe the reactions of carboxylic acids in the formation of esters			
					Explain the acidity of carboxylic acids and of chlorine-substituted ethanoic acids in terms of their structures	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
		Acyl chlorides			Describe the hydrolysis of acyl chlorides	Exemplified by ethanoyl chloride
					Describe the reactions of acyl chlorides with alcohols, phenols and primary amines	
					Explain the relative ease of hydrolysis of acyl chlorides, alkyl chlorides and aryl chlorides	
		Esters	Describe the formation of esters from carboxylic acids using ethyl ethanoate as an example	Exemplified by ethyl ethanoate	Describe the formation of esters from acyl chlorides using phenyl benzoate as an example	Exemplified by phenyl benzoate
			Describe the acid and base hydrolysis of esters		Describe the formation of polyesters	
			State the major commercial uses of esters e.g. solvents; perfumes; flavourings			

Organic Chemistry: Nitrogen compounds

Syllabus section	Theme	Topic	Learners studying AS and A2		***Additional*** **material for learners studying A2**	
			Things you should be able to do	**Comment**	**Things you should be able to do**	**Comment**
10.7	Nitrogen compounds	Primary amines			Describe the formation of alkyl amines by the reaction of ammonia with halogenoalkanes.	Exemplified by ethylamine
					Describe the formation of alkyl amines by the reduction of amides with $LiAlH_4$	
					Describe the formation of alkyl amines by the reduction of nitriles with $LiAlH_4$ or H_2/Ni	
					Describe the formation of phenylamine by the reduction of nitrobenzene by Sn/conc HC*l*	
					Describe and explain the basicity of amines	
					Explain the relative basicities of ammonia, ethylamine and phenylamine in terms of their structures	
					Describe the reaction of phenylamine with aqueous bromine	

Syllabus section	Theme	Topic	Learners studying AS and A2		***Additional*** **material for learners studying A2**	
			Things you should be able to do	**Comment**	**Things you should be able to do**	**Comment**
					Describe the reaction of phenylamine with nitrous acid to give the diazonium salt and phenol	
					Describe the coupling of benzenediazonium chloride and phenol and the use of similar reactions in the formation of dyestuff	
		Amides	Describe the formation of amides from the reaction between RNH_2 and $R'COCl$	Exemplified by ethanamide	Recognise that amides are neutral	
			Describe amide hydrolysis on treatment with aqueous alkali or acid		Describe the reduction of amides with $LiAlH_4$	

Syllabus section	Theme	Topic	Learners studying AS and A2		***Additional*** **material for learners studying A2**	
			Things you should be able to do	**Comment**	**Things you should be able to do**	**Comment**
10.7	Nitrogen compounds	Amino acids			Describe the acid/base properties of amino acids and the formation of zwitterions	Exemplified by aminoethanoic acid
		Proteins			Describe the formation of peptide bonds between amino acids and, hence, explain protein formation	
					Describe the hydrolysis of proteins	
					Describe the formation of polyamides	

Organic Chemistry: Polymerisation

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
10.8	Polymerisation	Addition polymerisation	Describe the characteristics of addition polymerisation as exemplified by poly(ethene) and PVC			
			Recognise the difficulty of the disposal of poly(alkene)s, i.e. non-biodegradability and harmful combustion products			
		Condensation polymerisation			Describe the characteristics of condensation polymerisation in polyesters as exemplified by Terylene	
					Describe the characteristics of condensation polymerisation in polyamides as exemplified by peptides, proteins, nylon 6 and nylon 6,6	
		Polymerisation			Predict the type of polymerisation reaction for a given monomer or pair of monomers	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
					Deduce the repeat unit of a polymer obtained from a given monomer or pair of monomers	
					Deduce the type of polymerisation reaction which produces a given section of a polymer molecule	
					Identify the monomer(s) present in a given section of a polymer molecule	

Applications of chemistry

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
11.1	The chemistry of life	Protein Chemistry			Recall that proteins are condensation polymers formed from amino acid monomers and recognise and describe the generalised structure of amino acids	
					Explain the importance of amino acid sequence (primary structure) in determining the properties of proteins	
					Distinguish between the primary, secondary and tertiary structure of proteins	
					State that the secondary structures found in proteins are α-helix and β-pleated sheet	
					Explain the stabilisation of secondary structure by hydrogen bonding between C=O and N-H groups in the backbone	
					Explain the stabilisation of tertiary structure by R-group interactions	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
					Describe and explain the characteristics of enzyme catalysis, including: (i) specificity and the idea of competitive inhibition; (ii) structural integrity in relation to denaturation and non-competitive inhibition	Using a simple lock and key model
					Given information, use core chemistry to explain how small molecules interact with proteins and how they can modify the structure and function of biological systems (for example, enzyme inhibitors or cofactors, disrupting protein-protein interactions, blocking ion channels)	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
11.1	The chemistry of life	Genetic information			Describe the double helical structure of DNA in terms of a sugar-phosphate backbone and attached bases	You will be expected to know the general structure in terms of a block diagram, but not detailed structures
					Explain the significance of hydrogen-bonding in the pairing of bases in DNA in relation to the replication of genetic information	
					Explain in outline how DNA encodes for the amino acid sequence of proteins with reference to mRNA, tRNA and the ribosome in translation and transcription	
					Explain the chemistry of DNA mutation from provided data	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
					Discuss the genetic basis of disease in terms of altered base sequence causing alterations in protein structure and function	For example, sickle cell anaemia
					Explain how modification to protein/enzyme primary structure can result in new structure and/or function	
		Energy			Outline, in terms of the hydrolysis of ATP to ADP + P_i, the provision of energy for the cell	
		Metals in biological systems			Understand why some metals are essential to life and, given information and with reference to chemistry of the core syllabus, be able to explain the chemistry involved	eg, iron in haemoglobin, Na and K in nerve cells, Zn as an enzyme cofactor
					Recognise that some metals are toxic and discuss, in chemical terms, the problems associated with heavy metals in the environment entering the food chain	For example, mercury

Syllabus section	Theme	Topic	Learners studying AS and A2		***Additional*** **material for learners studying A2**	
			Things you should be able to do	**Comment**	**Things you should be able to do**	**Comment**
11.2	Applications of analytical chemistry	Methods of detection and analysis			Describe simply the process of electrophoresis and the effect of pH, using peptides and amino acids as examples	
					Outline, in simple terms, the principles of nuclear magnetic resonance in ^{1}H and be able to interpret simple NMR spectra, using chemical shift values, splitting patterns, and the use of D_2O	
					Show awareness of the use of NMR and X-ray crystallography in determining the structure of macromolecules and in understanding their function	
					State what is meant by partition coefficient and calculate a partition coefficient for a system in which the solute is in the same molecular state in the two solvents	
					Understand qualitatively paper, high performance liquid, thin layer and gas/liquid chromatography in terms of adsorption and/or partition and be able to interpret data from these techniques	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
11.2	Applications of analytical chemistry				Explain the concept of mass spectroscopy, deduce the number of carbon atoms in a compound using the M+1 peak and the presence of bromine and chlorine atoms using the M+2 peak and suggest the identity of molecules formed by simple fragmentation in a given mass spectrum	
		Applications in chemistry and society			Explain, in simple terms, the technique of DNA fingerprinting and its applications in forensic science, archaeology and medicine	
					Describe the importance to modern medicine, and the challenges, of separating and characterising the proteins in cells	
					Draw conclusions given appropriate information and data from environmental monitoring	For example, PCBs in the atmosphere, isotopic ratios in ice cores

Syllabus section	Theme	Topic	Learners studying AS and A2		***Additional*** **material for learners studying A2**	
			Things you should be able to do	**Comment**	**Things you should be able to do**	**Comment**
11.3	Design and materials	Medicinal chemistry and drug delivery			Discuss the challenges of drug design and explain, in simple terms, how molecules may be identified and developed to overcome these problems	
					Discuss the challenges of drug delivery and explain, in simple terms, how materials may be developed to overcome these problems	
		Properties of polymers			Discuss the properties and structures of polymers based on their methods of formation	Both addition and condensation should be considered
					Discuss how the presence of side-chains and intermolecular forces affect the properties of polymeric materials	For example, spider silk
		Nanotechnology			Show awareness of nanotechnology and, given information and data, be able to discuss the chemistry involved with reference to the core syllabus	

Syllabus section	Theme	Topic	Learners studying AS and A2		*Additional* material for learners studying A2	
			Things you should be able to do	Comment	Things you should be able to do	Comment
		Environment and energy			Discuss how knowledge of chemistry can be used to overcome environmental problems	For example, ground water contamination, oil spillages, CFCs
					Discuss how knowledge of chemistry can be used to extend the life of existing resources, to identify alternative resources and to improve the efficiency of energy production and use.	

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