Approval of Subject knowledge enhancement (SKE) courses Criteria and guidance

Overview

We approve courses that provide effective subject knowledge enhancement for potential trainee teachers. We look for evidence that students are well prepared to begin a teacher training course on completion of their SKE course. Approval can be granted for any chemistry pre-ITT SKE courses available in England for the current academic year, and will be granted for five years.

Courses are assessed through a peer review process, involving a portfolio of evidence and a site visit by our assessors, who are experts in their field. We look for evidence related to:

- Course aims and objectives
- Length of the course
- Assessment and quality assurance
- Course delivery methods (including practical chemistry experience)
- Feedback and evaluation
- Health and safety
- Accessibility

Examples of suitable evidence against these criteria are given in the guidance below.

Please read the criteria and guidance below in detail before you submit your application. If you have any queries at any point, please email accreditation@rsc.org .

When you have read the criteria and guidance, complete the **Approval of Subject Knowledge Enhancement courses Application form** and submit it to accreditation@rsc.org, along with your portfolio of evidence.

1.0 Introduction

As part of the standards for attaining Qualified Teacher Status (QTS), trainee teachers must demonstrate a high level of subject knowledge and pedagogy. For science teachers this has added importance, because most are required to teach all three sciences to students up to age 16.

> *"Standard 3: Demonstrate good subject and curriculum knowledge - have a secure knowledge of the relevant subject(s) and curriculum areas, foster and maintain pupils' interest in the subject, and address misunderstandings."* (Teachers' Standards, DfE, 2011)

Pre-Initial Teacher Training Subject knowledge enhancement (pre-ITT SKE) courses are designed to up-skill potential trainee teachers by filling the gaps in their knowledge of their specialist subject. Courses can last from eight to 36 weeks, depending on the needs of the trainee. The courses can deliver knowledge up to either pre-16 or post-16 standard, and are funded entirely by the Department for Education. Trainees are put forward for a pre-ITT SKE course by their potential teacher training provider, and a teacher training place can be offered conditional on completion of a pre-ITT SKE course. Around a quarter of trainee chemistry teachers use pre-ITT SKE courses to develop their subject knowledge before beginning their teacher training course.[1]

Pre-ITT SKE providers may apply for approval of their courses. This highlights high quality training to students, schools and Initial Teacher Training (ITT) providers, and supports students in their subject knowledge development.

Our approval process is one of peer review, involving assessment against set criteria by members that are expert in their field. Outcomes of assessment are governed by the Admissions Committee and Education Division Council.

2.0 Eligibility

We will assess any chemistry pre-ITT SKE course available in England for the current academic year. This may include courses provided by HEIs, schools, colleges or third party suppliers, eg Science Learning Centres. These courses may be part-time or full-time, and include both online and face to face delivery methods.

The criteria for approval are outlined in this document. Approval is normally granted for five years, although annual review may be required at the discretion of the assessors.

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[1] http://www.score-education.org/media/14426/201403%20jb%20to%20sos%20for%20website.pdf

3.0 Application process

1. If you are interested in applying for approval, please contact us at accreditation@rsc.org to discuss the process before you begin your application.

2. Once you have decided to apply for approval, please complete the **Approval of Subject Knowledge Enhancement courses Application form**. You will also need to provide a portfolio of supporting evidence that the course meets the criteria detailed below. Note that the examples of evidence given are not exhaustive and not all examples will be relevant to all course types.

Please send your submission to accreditation@rsc.org, or, if hard copies are included, to:

Accreditation team
Royal Society of Chemistry
Thomas Graham House
290-292 Science Park
Milton Road
Cambridge
CB4 0WF

3. Our assessors and staff will arrange a site visit. The aim of the site visit is to find out more about the facilities and resources used to deliver the course, and to speak to the course tutors in more detail.

4. The assessors will review all the evidence collected from the application form and the site visit, and make one of the below decisions:

i. The course should be approved for a period of five years.
ii. The course should be approved for a period of five years, with annual review required.
iii. The course should be approved subject to specific recommendations being implemented. Further assessment of the course following implementation of recommendations will be necessary before approval can be finalised.
iv. The course should not be approved. Reapplication at a later date is permitted.

We reserve the right to remove approval at the discretion of our Admissions Committee

5. Once a course is approved, the Royal Society of Chemistry should be provided with updates of any significant changes to structure and/or materials.

4.0 Criteria

The approval process will assess the degree to which students will achieve the following competencies on completion of the course.

Chemistry pre-ITT SKE for pre-16	Chemistry pre-ITT SKE for post-16
Competent subject knowledge of chemistry at pre-16	Competent subject knowledge of chemistry at post-16
Ability to plan and deliver safely risk assessed practical experiments to support learning at pre-16	Ability to plan and deliver safely risk assessed practical experiments to support learning at post -16
Skills sufficiently developed to analyse and interpret data at pre-16	Skills sufficiently developed to analyse and interpret data at post -16
Skills sufficiently developed to communicate chemical concepts succinctly at pre-16	Skills sufficiently developed to communicate chemical concepts succinctly at post -16
Skills sufficiently developed to synthesise and simplify models and theories to explain chemical phenomena succinctly at pre-16	Skills sufficiently developed to synthesise and simplify models and theories to explain chemical phenomena succinctly at post -16
Ability to recognise and address misconceptions about chemical concepts at pre-16	Ability to recognise and address misconceptions about chemical concepts at post -16
Ability to use digital technologies competently to enhance the learning of chemistry at pre-16	Ability to use digital technologies competently to enhance the learning of chemistry at post -16
Develop and apply knowledge and understanding of chemistry in a wider context to support learning at pre-16	Develop and apply knowledge and understanding of chemistry in a wider context to support learning at post -16
Ability to plan and deliver qualitative experimental aspects to enhance learning at pre-16	Ability to plan and deliver qualitative experimental aspects to enhance learning at post -16
Ability to plan and deliver quantitative experimental aspects to enhance learning at pre-16	Ability to plan and deliver quantitative experimental aspects to enhance learning at post -16

The aspects of the SKE course which will be assessed are detailed below, along with suggestions of suitable evidence to meet each criterion. Please note that providers do not need to provide all the types of evidence suggested here.

1 Course aims

1.1 Students completing the course should demonstrate the competencies given above.

Appendix 1 contains a detailed subject knowledge audit which indicates the level of subject knowledge a trainee should have at the end of both a pre-16 and post-16 course. Appendix 2 contains guidance on the practical chemistry which should be undertaken as part of a pre-ITT SKE course.

1.2 The aims and intended learning outcomes of the course, and benefits to students, should be clear.

Suitable evidence:

- Webpage outlining course objectives, intended learning outcomes etc.
- Any material provided to participants in advance of the course.

2 Length of course

2.1 The length of the course should be determined by the SKE provider, and be indicative of individual students' needs, based on the outcome of an initial subject knowledge audit.

Suitable evidence:

- Subject knowledge audit used to assess students' needs
- Documentary record of process used for addressing students' needs

3 Assessment and quality assurance

3.1 The intended learning outcomes of the course should be clearly met on completion.

Suitable evidence:

In addition to self-assessment, SKE students will be assessed through a variety of means, evidence of which will be suitable for the approval process. These should include:

- Production of a portfolio of work
- Laboratory book

Evidence may also include any of the below:

- Formal end of course assessments
- Reflective logs
- Concept maps
- Micro-teaching and presentations
- Engagement in outreach activities

This evidence should be formally assessed and signed off by the course tutor, who should be a chemistry specialist.

4 Course delivery

4.1 Teaching and learning methods should be appropriate and should exemplify best practice in chemistry pedagogy.

Suitable evidence:

- Course materials, eg PowerPoint slides, hand-outs, workbooks
- For online courses, URL and associated details to access course

4.2 Appropriate materials and resources are provided to allow students to engage effectively with the course material, in particular with the practical chemistry aspects of the course

Suitable evidence:

- Examples of course materials and resources provided
- Evidence of resources available for practical aspects of the course

4.3 Course tutors should have qualifications and/or experience appropriate to their role and degree of involvement in the course.

Suitable evidence:

- Course tutor(s) CV(s) and certificates of qualification (eg CChem, CSciTeach)
- Documentary record of “Train the trainer” and CPD initiatives
- Documentary record of quality assurance processes

4.4 The mode of delivery of the course should be appropriate to provide students with sufficient knowledge and skills on completion of the course.

Participants for SKE can be taught through a variety of methods, some example of which are listed below. Providers should submit suitable evidence of the methods used, eg course timetables.

- Face to face tutorials (may include remote video tutorials eg Skype) – the recommended number being:
  - 8-15 week course – 2 tutorials
  - 16-23 week course – 3 tutorials
  - 24-36 week course – 4 tutorials
- On-site face-to-face teaching
- Laboratory based practical work
- Distance learning
- Blended learning
- Microteaching and presentations
- Engagement in outreach activities

Please note, **we recommend that at least 15% of the course is spent undertaking supervised laboratory work. A minimum of 10% may be considered acceptable at the discretion of the assessors.** Appendix 2 contains recommendations for the undertaking of practical chemistry in pre-ITT SKE courses.

5 Feedback and evaluation

5.1 Feedback should be requested from students, analysed and acted upon by the training provider.

Suitable evidence:

- Feedback forms distributed to students (during and/or after the course)
- Documentary record of updates/alterations to course as a result of participant feedback
- Documentary record of internal quality assurance processes

6 Health and safety

6.1 Student health and safety must be ensured while undertaking the course.

Suitable evidence:

- Risk assessment documentation
- Environment, health and safety guidance provided to participants
- Health and safety guidance and risk assessments for any practical activities undertaken as part of the course

7 Accessibility

7.1 Course providers should ensure that there are no exclusions to participation based on accessibility or specific learning difficulties, once participants have met the entry criteria

Suitable evidence:

- Document or webpage describing venue accessibility
- Description of accessibility of any websites used
- Evidence of consultation with appropriate organisations
- Diversity policy

5.0 Contact

If you have any queries about your application, or would like to receive more information, please contact us at accreditation@rsc.org.

Appendix 1: Subject knowledge content outcomes – theoretical chemistry

The following comprises an indicative audit of the key content and concepts a student should be familiar with on completion of an SKE course, for both pre- and post-16. This audit can be used directly with students to ascertain their depth of knowledge and understanding before, during and/or after their training course.

Although the particular elements may be covered in more than one age range, coverage of the concepts should be regarded as stage related.

Theme 1: Inorganic Chemistry

Atoms and atomic structure

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Explain the Particle Theory for solids, liquids and gases						✓	✓
Use particle theory to explain a range of phenomena eg evaporation, dissolution, freezing, boiling, melting, sublimation						✓	✓
Explain what is meant by the terms atom, element, molecule and compound						✓	✓
Give the main postulates of Dalton's atomic theory						✓	✓
Discuss the atomic model proposed by Dalton						✓	✓
Discuss the atomic model proposed by Thomson						✓	✓
Discuss and interpret the Rutherford gold foil experiment							✓
Discuss the Rutherford model of the atom							✓
Discuss the component particles of the atom (electron, proton, neutron)						✓	✓
Recall the relative mass and charge of a proton, neutron and an electron						✓	✓
Write the electronic configurations for the first 20 elements and draw their electronic diagrams						✓	✓
Write the electronic configurations for the first 36 elements using s, p and d notation							✓
Explain how the number of outer shell electrons is related to an element's group number in the periodic table						✓	✓
Explain the following terms							
• atomic number						✓	✓
• mass number						✓	✓
• isotope						✓	✓
• relative atomic mass						✓	✓

Relative formula masses and molar volumes of gases

The student is able to…	No knowledge				Excellent	pre-16	post-16
	5	4	3	2	1		
Explain the concept of the mole including: • Avogadro's number • Application to symbol equations						✓	✓
Calculate the relative atomic mass of an element from given relative abundances of its isotopes						✓	✓
Calculate relative formula masses (M_r) from relative atomic masses (A_r)						✓	✓
Use the term mole correctly (amount of a substance) and in the context of a calculation						✓	✓
Perform calculations using relative atomic mass (A_r) and relative formula mass (M_r)						✓	✓
Calculate the molar volume of a gas						✓	✓

Chemical formulae and chemical equations

The student is able to…	No knowledge				Excellent	pre-16	post-16
	5	4	3	2	1		
Calculate empirical and molecular formula from data (can also be experimental data)						✓	✓
Calculate the molar concentration of an unknown solution						✓	✓
Calculate the reacting mass of a substance using experimental data and chemical equations						✓	✓

Ionic compounds, covalent substances and metallic crystals

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Explain what oxidation is in terms of oxygen, hydrogen and electrons						✓	✓
Explain what reduction is in terms of oxygen, hydrogen and electrons						✓	✓
Explain how the charge of an ion can be deduced from the electronic configuration of its atom						✓	✓
Define that an ionic bond is a strong electrostatic attraction between oppositely charged ions						✓	✓
Draw and explain how ions and ionic bonding can be represented by 'dot and cross' diagrams e.g. NaCl, MgO, $CaCl_2$, $AlCl_3$ & Al_2O_3						✓	✓
Explain the relationship between ionic charge and the melting point and boiling point of an ionic compound						✓	✓
Draw and explain the positions of the ions in a crystal of sodium chloride						✓	✓
Define that a covalent bond is formed by the sharing of a pair of electrons between two atoms						✓	✓
Use 'dot and cross diagrams' to explain the covalent bonding for oxygen, nitrogen, methane, water, ammonia, carbon dioxide, ethane and ethene						✓	✓
Explain why simple molecular structures have low melting points in terms of the relatively weak forces between the molecules						✓	✓
Explain why giant covalent (macromolecular) structures have high melting points, in terms of the breaking of many strong covalent bonds						✓	✓
Draw and explain the molecular structures of diamond and graphite						✓	✓
Explain at least two uses of diamond and graphite, which depend on their properties						✓	✓
Explain the use of carbon in new technologies, eg nanotechnology and fullerenes						✓	✓

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Draw and explain how a metal is a giant structure of positive ions surrounded by a sea of delocalised electrons e.g. Na or K						✓	✓
Explain the malleability and electrical conductivity of a metal in terms of its structure and bonding						✓	✓
Explain the geometry of simple molecules using VSEPR theory, eg H_2O, NH_3, CH_4, CO_2, C_2H_4, C_2H_6, BF_3, SF_6							✓

Group I

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Explain the reactions of the elements in Group I with the following substances, their trends in reactivity and write balanced chemical equations for the reactions:							
• water						✓	✓
• oxygen						✓	✓
• chlorine						✓	✓
Explain the relative reactivity of the elements in Group I in terms of distance between the outer electrons and the nucleus						✓	✓

Group VII

The trainee is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Recall and explain the colours and physical states of the Group VII elements at room temperature						✓	✓
Explain the reactions of the halogens / halides (including balanced chemical equations) with the following substances:							
• water						✓	✓
• oxygen						✓	✓
• chlorine						✓	✓
Explain the above reactions in terms of electronegativity							✓
Explain and write balanced chemical equations for the reactions of Group VII non-metals with Group I metals						✓	✓
Write balanced chemical and ionic equations that explain how a more reactive halogen will displace a less reactive halogen from a solution of one of its salts (redox reactions)						✓	✓
Explain how to identify halide ions using silver nitrate						✓	✓
Understand why acidified silver nitrate solution is used as a reagent to identify and distinguish between F^- , Cl^- , Br^- , I^-						✓	✓
Describe the trend in solubility of the silver halides in ammonia							✓
Describe the uses of chlorine and chlorate(I)							
• Know the reactions of chlorine with water and the use of chlorine in water treatment							✓
• Appreciate that the benefits to health of water treatment by chlorine outweigh its toxic effects							✓
• Know the reaction of chlorine with cold, dilute, aqueous NaOH and the uses of the solutions formed							✓

Metals

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Explain how metals can be arranged in a reactivity series based on the reactions of the metals and their compounds						✓	✓
Electrode potentials							
Know the IUPAC convention for writing half-equations for electrode reactions							✓
Know and be able to use the conventional representation of cells							✓
Understand how cells are used to measure electrode potentials by reference to the standard hydrogen electrode							✓
Know the importance of the conditions when measuring the electrode potential, E							✓
Know that standard electrode potential, $E°$, refers to conditions of 298 K, 100 kPa and a 1.00 mol dm^{-3} solution of ions.							✓
Electrochemical series							
Know that standard electrode potentials can be listed as an electrochemical series							✓
Be able to use $E°$ values to predict the direction of simple redox reactions and to calculate the e.m.f of a cell							✓
Know the electrochemical series described by the reactions of metals with:							
• water						✓	✓
• dilute acids						✓	✓
Write balanced chemical equations for the displacement reactions, in the context of the reactivity series, between:							
• metals and their oxides						✓	✓
• metals and their salts in aqueous solutions						✓	✓
Define and explain the terms redox, half-reaction, oxidising agent and reducing agent						✓	✓
Construct redox equations using relevant half-equations, including for:						✓	✓
• copper and sodium hydroxide						✓	✓
• iron (II) and sodium hydroxide						✓	✓
• iron (III) and sodium hydroxide						✓	✓
• aluminium and sodium hydroxide						✓	✓

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Write full equations for the above reactions, including complex formulae							✓
Explain the conditions under which iron rusts and how to prevent rusting						✓	✓
Explain the sacrificial protection of iron in terms of the reactivity series							✓
Write balanced chemical equations (full and half) for all the reactions in this unit							✓
Complex formation							
Define the term "ligand"							✓
Know that co-ordinate bonding is involved in complex formation							✓
Understand that a complex is a central metal ion surrounded by ligands							✓
Know the meaning of the term "co-ordination number"							✓
Understand that ligands can be unidentate (e.g. H_2O, NH_3) and multidentate (e.g. EDTA)							✓
Know that haem is an iron(II) complex with a multidentate ligand							✓
Describe the formation and shape of linear, tetrahedral and octahedral complexes							✓

Acids, alkalis and salts

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Explain acids as sources of hydrogen ions, H^+, and alkalis as sources of hydroxide ions, OH^-						✓	✓
Predict the products of reactions between dilute hydrochloric, nitric and sulphuric acids; and metals, metal oxides and metal carbonates (excluding the reactions between nitric acid and metals)						✓	✓
Carry out the preparation of soluble salts from acids (see appendix 2)						✓	✓
Carry out the preparation of insoluble salts using precipitation reactions (see appendix 2)						✓	✓
Carry out acid-alkali titrations (see appendix 2)						✓	✓
Write balanced chemical equations for the above reactions						✓	✓
Explain the use of the indicators litmus, phenolphthalein and methyl orange to distinguish between acidic and alkaline solutions						✓	✓
Describe and explain the use of universal indicator to measure the approximate pH value of a solution						✓	✓
Describe and explain how the pH scale, from 0–14, can be used to classify solutions as strongly acidic, weakly acidic, neutral, weakly alkaline or strongly alkaline						✓	✓
Use the general rules for predicting the solubility of salts in water:							
• all common sodium, potassium and ammonium salts are soluble						✓	✓
• all nitrates are soluble						✓	✓
• common chlorides are soluble, except silver chloride						✓	✓
• common sulphates are soluble, except those of barium and calcium						✓	✓
• common carbonates are insoluble, except those of sodium, potassium and ammonium						✓	✓

Analysis

The trainee is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post 16
Describe and explain simple chemical tests for a range of cations, including: Cu^{2+}, Fe^{2+}, Fe^{3+}, Zn^{2+}, Al^{3+}, Pb^{2+}, NH^{4+}						✓	✓
Describe and explain simple chemical tests for the common anions: Cl^-, Br^-, I^-, CO_3^{2-}, SO_4^{2-}, NO_3^-						✓	✓
Describe simple flame tests for Li^+, Na^+, K^+, Ca^{2+}, Ba^{2+}, Cu^{2+} (Sr^{2+} if available)						✓	✓
Describe and explain simple tests for the gases:							
• hydrogen						✓	✓
• oxygen						✓	✓
• carbon dioxide						✓	✓
• ammonia						✓	✓
• chlorine						✓	✓

Theme 2 – Organic Chemistry

The majority of the subject content in this theme is at higher level pre-16 chemistry or post-16 chemistry.

Organic basics and nomenclature

The student is able to…	No knowledge			Excellent		pre-16	post-16
	5	4	3	2	1		
Define the following terms:							
hydrocarbon						✓	✓
saturated						✓	✓
unsaturated						✓	✓
homologous series						✓	✓
empirical formula						✓	✓
molecular formula						✓	✓
general formula						✓	✓
structural formula						✓	✓
displayed formula						✓	✓
skeletal formula						✓	✓
structural isomers						✓	✓
stereoisomers							✓
E/Z isomerism							✓
cis-trans isomerism							✓
free radical							✓
alkanes						✓	✓
alkenes						✓	✓
halogenoalkanes						✓	✓
alcohols						✓	✓
carboxylic acids						✓	✓
esters						✓	✓
homolytic fission							✓
heterolytic fission							✓
percentage yield of a reaction						✓	✓
atom economy of a reaction						✓	✓

Alkanes

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Explain why alkanes are described as saturated hydrocarbons						✓	✓
Describe and explain the fractional distillation of crude oil and its uses and the continued debate over the use of crude oil						✓	✓
Draw the molecular, displayed and skeletal formulae for alkanes with up to six carbon atoms in a molecule, and name the straight-chain isomers						✓	✓
Describe the complete and incomplete combustion of alkanes, with balanced chemical equations, and describe their use as fuels in industry, in the home and in transport						✓	✓
Describe the use of catalytic cracking to obtain more useful alkanes and alkenes						✓	✓
Describe and draw the free radical substitution reaction in alkanes in terms of initiation, propagation and termination reactions							✓
Describe and explain how a catalytic convertor operates in a motor vehicle						✓	✓

Alkenes

The student is able to…	No knowledge 5	4	3	2	Excellent 1	11-16	Post-16
Explain why alkenes are described as unsaturated hydrocarbons						✓	✓
Draw the molecular, displayed and skeletal formulae for alkenes with up to six carbon atoms in a molecule, and name the straight-chain isomers						✓	✓
Describe how the C=C double bond is formed in terms of a sigma and pi bond and its trigonal planar shape						✓	✓
Describe the reaction of alkenes with hydrogen						✓	✓
Describe the reaction of alkenes with halogens						✓	✓
Describe the reaction of alkenes with hydrogen halides						✓	✓
Describe the reaction of alkenes with steam						✓	✓
Describe and write the balanced chemical equation for the test for a C=C double bond						✓	✓
Write the electrophilic addition reaction for an alkene reacting with a hydrogen halide, including the mechanism for the reaction							✓
Describe and write equations for addition polymerisation of alkenes, including in:						✓	✓
• manufacture of margarine						✓	✓
• formation of a range of polymers						✓	✓
Outline the potential drawbacks from waste polymers and how the government is addressing this						✓	✓

Halogeno-alkanes and alcohols

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	Post-16
Draw the molecular, displayed and skeletal formulae for halogenoalkanes (chlorine) with up to six carbon atoms in a molecule, and name the isomers						✓	✓
Define the terms “nucleophile” and “nucleophilic substitution”							✓
Outline the nucleophilic substitution reaction for an OH^- ion reacting with a halogenoalkane, and outline the mechanism for the reaction							✓
Outline the uses of CFCs and the potential issues with using them						✓	✓
Draw the molecular, displayed and skeletal formulae for alcohols with up to six carbon atoms in a molecule, and name the isomers, identifying if they are primary, secondary or tertiary alcohols						✓	✓
Describe and draw a diagram of hydrogen bond formation in ethanol							✓
Describe the manufacture of ethanol by fermentation						✓	✓
Describe the manufacture of ethanol by the reaction between ethene with steam						✓	✓
Write balanced chemical equations for the combustion of the first four alcohols						✓	✓
Outline, with balanced chemical equations, the oxidation of primary, secondary and tertiary alcohols							✓
Outline, with balanced chemical equations, the esterification of alcohols with carboxylic acids						✓	✓
Outline, with balanced chemical equations, how alcohols can be used to form alkenes						✓	✓

Carboxylic acids and esters

The student is able to…	No knowledge				Excellent	pre-16	post-16
	5	4	3	2	1		
Draw the molecular, displayed and skeletal formulae for carboxylic acids with up to six carbon atoms in a molecule, and name the isomers						✓	✓
Outline, with balanced chemical equations, the reactions of carboxylic acids with:							
• metals						✓	✓
• metal carbonates						✓	✓
• hydroxides						✓	✓
• metal oxides						✓	✓
Outline as many combinations as possible, with balanced chemical equations, of the esterification of the first four carboxylic acids with the first four alcohols						✓	✓
Describe the uses of esters in perfumes and flavourings						✓	✓

Further organic chemistry

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Aldehydes and Ketones							
Describe the key structural features of carbonyl compounds							✓
Know that aldehydes are readily oxidised to carboxylic acids and that this forms the basis of a simple chemical test to distinguish between aldehydes and ketones (eg Fehling's solution and Tollens' reagent)							✓
Describe the reactions of aldehydes and ketones with HCN/KCN							✓
Understand the mechanism of the reaction of carbonyl compounds with HCN as a further example of nucleophilic addition producing hydroxynitriles							✓
Appreciate the hazards of synthesis using HCN/KCN							✓
Know that aldehydes can be reduced to primary alcohols and ketones to secondary alcohols using reducing agents such as $NaBH_4$. (Mechanisms showing [H] as reductant are acceptable)							✓
Aromatic Chemistry							
Understand the nature of the bonding in benzene – limited to planar structure, bond length and delocalisation of electrons							✓
Understand that delocalisation confers stability to the molecule							✓
Be able to use thermochemical evidence from enthalpies of hydrogenation to illustrate this principle of stability due to delocalisation							✓
Electrophilic substitution							
Understand that electrophilic attack in arenes results in substitution (mechanisms limited to nitration and acylation)							✓

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Nitration							
Understand that nitration is an important step in synthesis eg manufacture of explosives and formation of amines from which dyestuffs are manufactured							✓
Understand the mechanism of nitration, including the generation of the nitronium ion							✓
Friedel-Crafts acylation reactions							
Understand that Friedel–Crafts acylation reactions are important steps in synthesis							✓
Understand the mechanism of acylation using aluminium chloride as a catalyst							✓

Analytical techniques

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Infrared spectroscopy							
Outline how infrared radiation is absorbed in covalent molecules, and how the following molecules can be identified:							✓
• an alcohol from an absorption peak of the O-H bond							✓
• an aldehyde or ketone from an absorption peak of the C=O bond							✓
• a carboxylic acid from an absorption peak of the C=O and broad O-H bond							✓
Mass spectrometry							
Outline the use of mass spectrometry for the determination of isotopic masses							✓
Interpret a mass spectrum for ions with single charges and use this information to determine molecular mass							✓
NMR spectroscopy							
Understand that NMR gives information about the position of ^{13}C or ^{1}H atoms in a molecule							✓
Understand that ^{13}C NMR gives a simpler spectrum than ^{1}H NMR							
Know the use of the δ scale for recording chemical shift							
Interpret simple ^{13}C and ^{1}H spectra							

Theme 3 – Physical Chemistry

Energetics

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Explain that chemical reactions in which heat energy is given out are described as exothermic and those in which heat energy is taken in are endothermic						✓	✓
Understand the use of Δ*H* to represent molar enthalpy change for exothermic and endothermic reactions						✓	✓
Represent exothermic and endothermic reactions on a simple energy level diagram						✓	✓
Use enthalpy profile diagrams to explain the term *activation energy* in terms of the following types of reaction						✓	✓
• combustion						✓	✓
• displacement							✓
• dissolving							✓
• neutralisation							✓
Calculate molar enthalpy change from heat energy change						✓	✓
Use average bond energies to calculate the enthalpy change during a simple chemical reaction						✓	✓

Rates of reaction

The student is able to…	No knowledge 5	4	3	2	Excellent 1	pre-16	post-16
Investigate the effects of changes in the following factors on the rate of a reaction, in terms of particle collision theory:						✓	✓
• surface area of a solid						✓	✓
• concentration of a solution						✓	✓
• pressure of a gas						✓	✓
• temperature						✓	✓
• a catalyst						✓	✓
Explain, using enthalpy profile diagrams, how the presence of a catalyst allows a reaction to proceed via a different route with a lower activation energy, giving rise to an increased reaction rate						✓	✓
Describe and explain the effect of a change in temperature and the use of a catalyst on a Maxwell-Boltzmann Distribution							✓
Simple rate equations Understand and be able to use rate equations of the form Rate = $k[A]^m [B]^n$ where m and n are the orders of reaction with respect to reactants A and B (m, n restricted to values 1, 2 or 0)							✓
Determination of rate equation Be able to derive the rate equation for a reaction from data relating initial rate to the concentrations of the different reactants							✓
Be able to explain the qualitative effect of changes in temperature on the rate constant							✓
Understand that the orders of reactions with respect to reactants can be used to provide information about the rate determining/limiting step of a reaction							✓

Equilibria

The student is able to…	No knowledge				Excellent	pre-16	post-16
	5	4	3	2	1		
Explain that a reversible reaction is indicated by the symbol ⇌ in equations						✓	✓
Explain reversible reactions such as the dehydration of hydrated copper(II) sulphate and the effect of heat on ammonium chloride						✓	✓
Explain the concept of a dynamic equilibrium						✓	✓
Predict the effects of changing the following variables on the equilibrium position in reversible reactions in a homogeneous system in equilibrium:							
• temperature						✓	✓
• concentration						✓	✓
• pressure						✓	✓
State le Chatelier's principle						✓	✓
Equilibrium constant for homogeneous systems							
Know that K_c is the equilibrium constant calculated from equilibrium concentrations for a system at constant temperature							✓
Be able to construct an expression for K_c for an homogeneous system in equilibrium; be able to perform calculations involving such an expression.							✓
Qualitative effects of changes in temperature and concentration							
Be able to predict the effects of changes of temperature on the value of the equilibrium constant							✓
Understand that the value of the equilibrium constant is not affected by either changes in concentration or the addition of a catalyst							✓

Industrial manufacture of chemicals

The student is able to…	No knowledge				Excellent	pre-16	post-16
	5	4	3	2	1		
Explain that nitrogen from air, and hydrogen from natural gas or the cracking of hydrocarbons, are used in the manufacture of ammonia						✓	✓
Explain the manufacture of ammonia by the Haber process, including the essential conditions: temperature of about 450°C, pressure of about 200 atmospheres, iron catalyst.						✓	✓
Explain that the cooling of the reaction mixture liquefies the ammonia produced and allows the unused hydrogen and nitrogen to be recycled						✓	✓
Explain the use of ammonia in the manufacture of nitric acid and fertilisers						✓	✓
Describe the raw materials used in the manufacture of sulphuric acid by the contact process, and explain why the essential conditions are optimal: temperature of about 450 °C, pressure of about 2 atmospheres, vanadium(V) oxide catalyst						✓	✓
Explain the conflict between the best conditions for equilibria and the best conditions for reaction rate							✓
Explain the use of sulphuric acid in the manufacture of detergents, fertilisers and paints						✓	✓
Explain the manufacture of sodium hydroxide and chlorine by the electrolysis of concentrated sodium chloride solution (brine) in a diaphragm cell						✓	✓
Write ionic half-equations for the reactions at the electrodes in the diaphragm cell in the manufacture of sodium hydroxide						✓	✓
Explain the uses of sodium hydroxide, including the manufacture of bleach, paper and soap; and of chlorine, including sterilising water supplies and in the manufacture of bleach and hydrochloric acid.						✓	✓

Appendix 2: Subject knowledge content outcomes – practical chemistry

All practical work should be risk-assessed by the student prior to being undertaken. There should be some practical activities that allow the students to identify a question, plan practical work and carry it out, followed by analysis and evaluation of results.

The following represents a sample of the recommended practical activities that could be undertaken by a pre-ITT SKE Chemistry student.

- Test tube reactions involving precipitation, neutralisation, evolution of gases (with tests)
- Simple separation techniques
- Acid/base titration, including making up a standard solution and dilution to give a known concentration
- Preparation of salts
- Experiment involving potential for suckback (eg cracking)
- Experimental determination of an enthalpy change
- Preparation involving quickfit (eg oxidation of propan-1-ol, oil of wintergreen hydrolysis)
- Practically investigate the tests for chloro-, bromo- and iodo-alkanes
- Investigation of factors affecting rate of reaction
- Opportunities to practice demonstrations such as flaming hands, thermite, etc.…

Other suitable practical activities could be sourced from:

- http://www.rsc.org/learn-chemistry/resource
- http://www.nuffieldfoundation.org/practical-chemistry
- http://saltersinstitute.co.uk/about/