Geochemistry

Programme Requirements:

MSc Geochemistry - MSc
45 credits from Module List: ES3008, ES5005, CH3721, ES4031 **and** (15 credits from Module List: ES5300, ES5011, ES5013, ES5301 **or** 10 credits from Module List: CH5511, CH5716) **and** 45 credits from Module List: ES5010, ES5050 - ES5051 **and** (15 credits from Module List: ES5012, ES5302 **or** 20 credits from Module List: CH5517 - CH5518, CH5715) **and** ES5099 (60 credits) 1. Entrants with a BSc Geology or Environmental Earth Sciences from St Andrews can substitute ES3011, ES3009, and ES5009 for any of the listed ES modules. 2. Entrants with a BSc in Chemistry may substitute CH3513, CH4514, CH4714 or CH5711 in place of CH3721.

Compulsory modules:

ES3008 Geochemistry

SCOTCAT Credits:	15	SCQF Level 9	**Semester**	1
Academic year:	2018/9			
Planned timetable:	10.00 am Tue and Thu (lectures), 2.00 - 5.00 Fri (practicals)			
This module provides an introduction to geochemistry: the study of the abundance, distribution and circulation of the chemical elements in minerals, rocks, soils, water and the atmosphere. Geochemical tools are a powerful means to the study of geological, economic, and environmental problems. In the module we study the origin and distribution of the chemical elements in the Earth and solar system and review thermodynamics and kinetics as applied to Earth systems. We apply thermodynamics to make quantitative predictions regarding the outcome of chemical reactions associated with geological processes. We consider the behaviour of elements, mainly in low temperature environments. Material covered includes aqueous geochemistry and mineral precipitation and dissolution. We utilise geochemical tools to constrain changes in earth processes and climate, and to predict the impact of future change.				
Pre-requisite(s):	Before taking this module you must take at least 1 and no more than 2 modules from {ES2001, ES2003}			
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1 hour lectures (8 weeks), 1 x 3 hour practical (8 weeks), 1 field class			
Assessment pattern:	2-hour Written Examination = 50%, Coursework = 50%			
Re-assessment pattern:	2-hour Written Examination = 80%, Coursework = 20%, No Re-assessment if Coursework mark is <4			
Module coordinator:	Dr N Allison			
Module teaching staff:	Dr N Allison, Prof A Finch, Dr J Rae, Dr P Savage			

ES5005 Isotope Geochemistry: Theory, Techniques, and Applications

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2018/9			
Planned timetable:	To be arranged.			
Isotope geochemistry has grown over the last 50 years to become one of the most important fields in the Earth sciences. The growth in the importance of isotope geochemistry reflects its remarkable success in solving fundamental problems in mantle formation, ore genesis, hydrology, hydrocarbon formation, crustal evolution, planetary formation, geochemical cycles, hydrothermal circulation, ocean circulation, and climate and environmental change. In this module, we will explore the theory of isotopes and their fractionation, including kinetic, equilibrium, and Rayleigh fractionation. We will also use case studies and applications of isotopes to interesting problems across Earth Sciences including the evolution of the atmosphere, the formation of the solar system and planets, and climate and carbon cycle reconstructions. These case studies will introduce concepts such as clumped isotopes, isotope mass balance, mass independent fractionation, and radionuclide disequilibria.				
Pre-requisite(s):	Current bsc students should pass ES3008 or pass (ch1401, CH1402 and ch2501)			
Learning and teaching methods of delivery:	**Weekly contact**: 2 x2-hour lectures (x 5 weeks), 3-hour practical sessions (x 3 weeks)			
Assessment pattern:	2-hour Practical (Open Book) Examination = 50%, Coursework = 50%			
Re-assessment pattern:	2-hour Practical (Open Book) Examination = 80%, Coursework = 20%			
Module coordinator:	Dr A Burke			
Module teaching staff:	Dr A Burke, Dr P Savage, Dr A Zerkle			

ES4031 Analytical Sciences

SCOTCAT Credits:	5	SCQF Level 10	**Semester**	1
Academic year:	2018/9			
Availability restrictions:	Available to students on the MSc Geochemistry degree and Geography Honours programme.			
Planned timetable:	To be arranged.			
This module is designed to support students who do not have a strong background in the analytical methods used in Earth Science. These include, for example, students enrolled in BSc Geography or MSc Geochemistry degree programmes. The module comprises a series of seven lectures starting with the basic principles of accuracy and precision, which are then illustrated in the context of the most common analytical methods used in the geosciences. Students are asked to independently research an analytical method of interest. This is then presented in a poster imitating the poster sessions at major conferences. Posters are marked by both students (peer assessment) and staff (different weighting). The module will give students the necessary training to allow them to excel in other Earth Science modules.				
Anti-requisite(s)	You cannot take this module if you take EG4031			
Co-requisite(s):	Any level 4 or 5 module for bsc students			
Learning and teaching methods of delivery:	**Weekly contact**: 7 x 1-hour lectures and 1 x 8-hour poster presentation day over the semester.			
Assessment pattern:	Coursework (Poster session) = 100%			
Re-assessment pattern:	No Re-assessment available			
Module coordinator:	Dr R J S Wilson			
Module teaching staff:	Earth and Environmental Sciences staff			

CH3721 Physical Chemistry Laboratory

SCOTCAT Credits:	10	SCQF Level 9	**Semester**	1
Academic year:	2018/9			
Planned timetable:	9.00 am - 1.00 pm Mon to Fri (Weeks 7-10)			
This module comprises practical experiments involving physical measurements and the use of computational programmes in Chemistry.				
Pre-requisite(s):	Before taking this module you must pass CH2701 and pass at least 1 module from {CH2501, CH2601, CH2603}			
Learning and teaching methods of delivery:	**Weekly contact**: Daily 4-hour morning practical classes over 4 weeks (Weeks 7 - 10).			
Assessment pattern:	Coursework = 100%			
Re-assessment pattern:	No Re-assessment available, requires lab attendance to complete coursework			
Module coordinator:	Prof M Buck			
Module teaching staff:	Prof P A Wright, Prof M Buck, Dr R Schaub, Dr T van Mourik, Prof M Buehl			

ES5010 Advanced Geochemistry

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2018/9			
Planned timetable:	To be arranged.			
The objective of this course is to provide students with skills in some of the more advanced topic in geochemistry that are not commonly discussed in introductory courses, including isotope geochronology, aqueous geochemical modeling, non-traditional stable isotopes and organic geochemistry. This selection of topics covers both theoretical and applied aspects in geochemical sciences with the aim of laying out potential avenues for future professional development.				
Pre-requisite(s):	Before taking this module you must take ES3008			
Learning and teaching methods of delivery:	**Weekly contact**: 1-hour lecture (x 10 weeks) 7 x 3-hour practical sessions and 1 x 2-hour session of group presentations over the semester.			
Assessment pattern:	Coursework = 100%			
Re-assessment pattern:	2-hour Written Examination = 80%, Coursework = 20%, No Re-assessment if Coursework mark is <4			
Module coordinator:	Dr E E Stueeken			
Module teaching staff:	Prof D Mark			

ES5050 Earth's Greatest Hits

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2018/9			
Availability restrictions:	Available to General Degree students with the permission of the Honours Adviser			
Planned timetable:	Lectures: 11.00 am - 12.00 noon Thu, Seminars: 10.00 am - 1.00 pm Wed			

This module is based around current hot topics in Earth science research. It will introduce cutting-edge science questions about how our planet has evolved from a ball of molten rock to the habitable blue planet it is today, and some of the major changes in its chemistry, biosphere, and climate that have happened along the way. Topics will vary from year to year, depending on staff participating in the module and the advances in Earth science research. This module is research-led, requiring that you read, digest, and discuss a number of topical papers each week. For some of these topics there is no given answer; instead you gain an in-depth understanding of the current state of research. Topics are introduced in lectures and then discussion seminars, organised around student presentations, are designed to encourage debate and critique of the arguments presented in the research papers.

Pre-requisite(s):	Undergraduate students should pass ES2001 and (pass ES2002 or pass es2003)
Learning and teaching methods of delivery:	**Weekly contact**: 8 hours of lectures and 24 hours of seminars over the semester.
Assessment pattern:	Coursework (10% participation in discussion groups; 60% oral presentations; 30% review paper) = 100%
Re-assessment pattern:	2-hour Written Examination = 100% No ReaAssessment if Coursework mark is <4
Module coordinator:	Dr J W B Rae
Module teaching staff:	Earth & Environmental Sciences academic and research staff

ES5051 Geochemistry Field Excursion

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2018/9			
Planned timetable:	2 weeks of field work and post-trip analysis in April			

Field sampling and laboratory analysis of natural samples are in important part of a geochemists' toolkit. This module will introduce the skills necessary for planning and executing a successful field campaign, developing best practice field skills in documenting the geological and environmental controls on a geochemical problem, and how to select and take samples. This forms the introduction to methodologies and training in applied environmental problems. Specific environmental problems will be identified, and researched in detail before a one-week field excursion to Rio Tinto in southern Spain, a world-famous environmental mining disaster.

Learning and teaching methods of delivery:	**Weekly contact**: Occasional seminar, 6 hours of lectures and labs in Week 10 and week long field trip in Week 11.
Assessment pattern:	Coursework = 100%
Module coordinator:	Dr M Claire
Module teaching staff:	Dr M Claire, Dr J Cloutier, Dr A Zerkle, Dr. E StuÙken

ES5099 Research Project

SCOTCAT Credits:	60	SCQF Level 11	**Semester**	Both
Academic year:	2018/9			
Planned timetable:	To be arranged.			
This module provides an opportunity to conduct independent research with an academic supervisor, usually within a research group. The research topic is defined by the student and can be chosen from research foci within the School. The research project will involve project formulation, a background literature review, proposal writing, and analytical design, as well as data integration and interpretation. The results are presented as oral presentations, as a poster as part of a conference, and in a dissertation.				
Learning and teaching methods of delivery:	**Weekly contact**: introductory lectures, presentations and supervisory meetings.			
Assessment pattern:	Coursework (10,000 word dissertation + other elements) = 100%			
Re-assessment pattern:	No Re-assessment available			
Module coordinator:	Dr P S Savage			
Module teaching staff:	TBC Module coordinator(s): Dr P Savage/Dr J Clouteier			

Optional modules:

ES5300 Magmatic-related Ore Deposits

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2018/9			
Planned timetable:	To be arranged.			
The module focuses on the geodynamic setting, age, geometry, and mineralogy of the principal metallic mineral deposits related to magmatic processes. The different deposit types are studied using a holistic (geology, structural, geochemistry, and geophysics) mineral system approach. Current genetic models of ore deposits related to magmatic processes are reviewed with an emphasis on the geological processes required to create them. Finally, a roadmap to mineral exploration for each type of ore deposit is discussed. Deposit types discussed include magmatic Ni-Cu, magmatic PGE-Cr, porphyry, epithermal, skarn, Rare Earth Element (REE) and iron oxide copper gold (IOCG). Laboratory exercises involve geological problem solving using a mineral exploration industry focus involving the examination of geological maps and representative suites of samples (thin sections and hand samples) from different types of metallic mineral deposits.				
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1-hour lectures (22 hours over 10 weeks), 3 x 1-hour seminars (x 2 weeks); 3-hour practical classes (x 4 weeks)			
Assessment pattern:	2-hour Written Examination = 50%, Practical Examination = 15%, Coursework = 35%			
Re-assessment pattern:	2-hour Written Examination = 80%, Existing Coursework = 20%			
Module coordinator:	Dr J Cloutier			
Module teaching staff:	Dr J Cloutier and Prof A Finch			

ES5011 Water in the Environment

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2018/9			
Planned timetable:	To be arranged.			
This module provides an introduction to hydrogeology (the distribution and movement of water through rocks and soils) and water quality and contamination. In the module we study the theory and concept of hydrology and groundwater flow, how to model fluid flows and how to predict solute and contaminant transport. We study key aqueous pollutants (e.g. metals, radionuclides, nutrients), their behaviour in different waters (speciation, mobility, bioavailability and toxicity) and methods of remediation.				
Pre-requisite(s):	Undergraduate students without the prerequisite but with a suitable chemistry background should be considered			
Learning and teaching methods of delivery:	**Weekly contact**: Total of 20 hours of lectures, 9 hours of practicals, one field trip and interviews.			
Assessment pattern:	2-hour Written Examination = 40%, Coursework (including Technical Brief, Media Interview and Qualitative analysis exercise) = 60%			
Re-assessment pattern:	2-hour Written Examination = 100%			
Module coordinator:	Dr N Allison			
Module teaching staff:	Dr N Allison, Mr A Black (Groundwater Science Ltd)			

ES5012 Biogeochemistry

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2018/9			
Planned timetable:	To be arranged.			
Earth's surface environment is tightly regulated by biogeochemical processes. The biosphere directly influences the composition of Earth's atmosphere, ocean chemistry, and global climate, through the cycling of nutrients and other elements. This module will examine the role of biogeochemical processes in controlling Earth surface chemistry, and their possible influence on deep Earth reservoirs. Emphasis will be placed on feedbacks between the geosphere, atmosphere, and biosphere over geologic time, and how these interactions have both contributed and responded to important transitions in Earth history (e.g., the Great Oxidation Event, global glaciations). We will also highlight current geochemical (e.g., stable isotope ratios) and numerical (e.g., modelling) techniques used to constrain these interactions in both modern and ancient (rock record) systems.				
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1-hour lectures and 3-hour practical sessions.			
Assessment pattern:	2-hour Written Examination = 40%, Coursework (including modelling exercises, literature review and project) = 60%			
Re-assessment pattern:	2-hour Written Examination = 80%, existing Coursework = 20%			
Module coordinator:	Dr A L Zerkle			
Module teaching staff:	Dr A Zerkle, Dr M Claire, Dr S Mikhail			

ES5013 Advanced Petrogenesis

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2018/9			
Planned timetable:	10.00 am Mon and Tue (lectures). 10.00 - 1.00 pm Wed or Fri (practicals)			

Rocky planets, like Earth, comprise of a metallic core with a rocky mantle and crust topped with a gaseous atmosphere. The focus of this course is the genesis of the rocky mantle and crust ? termed the silicate Earth ? and it?s relationship to small-scale to planetary-wide processes. The silicate Earth primarily comprises igneous and metamorphic rocks. This module explores the nature of the magmatic and metamorphic processes that characterise the Earth from the immediate subsurface to the base of the mantle. We focus on the petrology and geochemistry of the minerals and rocks created, and the evolution of composition as a function of time and depth. Students completing this module will understand how magmatic systems operate from melting source, through ascent to the plumbing systems in the immediate subsurface. The response of the crust to dynamic changes in pressure and temperature will also be explained along with the methods used to determine these. The course will develop key skills in identifying rocks, interpreting geochemical data, and using geochemical and thermodynamic methods to unravel rock histories. Students will also be shown how these data can be used to understand any and all rocky bodies in the cosmos, from Earth to exoplanets.

Pre-requisite(s):	Before taking this module you must take ES3009
Learning and teaching methods of delivery:	**Weekly contact**: 18 lectures, 15 hours of laboratory work, 18 hours of field-related study over the semester
Assessment pattern:	2-hour Written Examination = 50%, 3-hour Practical Examination = 50%
Re-assessment pattern:	2-hour Written Examination = 100%, No Re-assessment if Coursework mark is <4
Module coordinator:	Prof A A Finch
Module teaching staff:	Prof A Finch, Prof R White and Dr S Mikhail

ES5301 Mineral Exploration

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2018/9			
Planned timetable:	To be arranged.			

The purpose of this module is to learn basic concepts of mineral exploration that are used by the mineral exploration industry. The module is divided into three sections each focusing on different aspect of mineral exploration. Section 1 focuses on geochemical methods, section 2 on hyperspectral methods, and section 3 on geophysical methods. Each section discusses the theoretical background necessary to understand the different methods and introduces the different available analytical techniques, and highlights effective data acquisition. Finally, interpretation and application of datasets related to each method is conducted as practical exercises.

Pre-requisite(s):	Student must have gained entrance to the mgeol or msc mineral resources
Learning and teaching methods of delivery:	**Weekly contact**: 2 lectures (x 11 weeks), 1 practical (x 2 weeks)
Assessment pattern:	Coursework = 50%, 2-hour Written Examination = 50%
Re-assessment pattern:	2-hour Written Examination = 80%, grade derived from Previous Coursework = 20%
Module coordinator:	Dr J Cloutier
Module teaching staff:	Dr J Cloutier, Dr R Bates

ES5302 Hydrothermal Ore Deposits

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2018/9			
Planned timetable:	To be arranged.			
The module focuses on the geodynamic setting, age, geometry, and mineralogy of the principal metallic mineral deposits related to hydrothermal processes. The different deposit types are studied using a holistic (geology, structural, geochemistry, and geophysics) mineral system approach. Current genetic models of ore deposits related to hydrothermal processes are reviewed with an emphasis on the geological processes required to create them. Finally, a roadmap to mineral exploration for each type of ore deposit taught is discussed. Deposit type discussed in the module includes orogenic gold, VMS, SEDEX, Mississippi Valley-type, unconformity-related uranium deposits, and sedimentary-hosted stratiform copper deposits. Laboratory exercises involve geological problem solving using a mineral exploration industry focus involving the examination of geological maps and representative suites of samples (thin sections and hand samples) from different types of metallic mineral deposits.				
Pre-requisite(s):	Student must have gained entrance to the mgeol or msc mineral resources programmes			
Learning and teaching methods of delivery:	**Weekly contact**: 2 lectures (x 11 weeks), 1 practical (x 3 weeks), 1 field trip			
Assessment pattern:	2-hour Written Examination = 50%, Coursework = 50%			
Re-assessment pattern:	2-hour Written Examination = 80%, Existing Coursework = 20%			
Module coordinator:	Dr J Cloutier			

CH5511 Homogeneous Catalysis

SCOTCAT Credits:	10	SCQF Level 11	**Semester**	1
Academic year:	2018/9			
Planned timetable:	To be arranged.			
This module discusses the use of metal based systems in organic transformations and a detailed treatment of homogeneous catalysis. Important processes in the petrochemicals industry will be used to exemplify the principles described.				
Learning and teaching methods of delivery:	**Weekly contact**: 2 - 3 lectures per week over 9 - 10 weeks (within Weeks 1-11) and 2 - 3 tutorials in total.			
Assessment pattern:	2-hour Written Examination = 100%			
Re-assessment pattern:	Oral Re-assessment = 100%			
Module coordinator:	Dr P B Webb			
Module teaching staff:	Prof R P Tooze, Dr P Webb			

CH5715 Energy Conversion and Storage

SCOTCAT Credits:	10	SCQF Level 11	**Semester**	2
Academic year:	2018/9			
Planned timetable:	To be arranged.			
In our efforts to mitigate global warming it is essential to develop new and improved methods of generation and storage of energy. Foremost among these methods are the electrochemical technologies of batteries and fuel cells. In this module we will discuss the technical details and applications of such devices. Particular emphasis will be placed on the underlying electrochemistry and materials chemistry.				
Anti-requisite(s)	You cannot take this module if you take CH4712			
Learning and teaching methods of delivery:	**Weekly contact**: 2 - 3 lectures per week over 9 - 10 weeks (within Weeks 1-11) and 2 - 3 tutorials in total.			
Assessment pattern:	2-hour Written Examination = 100%			
Re-assessment pattern:	Oral Re-assessment = 100%			
Module coordinator:	Dr R T Baker			
Module teaching staff:	Dr R T Baker, Prof J T S Irvine, Dr A R Armstrong			

CH5716 Processing of Materials

SCOTCAT Credits:	10	SCQF Level 11	**Semester**	1
Academic year:	2018/9			
Planned timetable:	To be arranged.			

This module focuses on the processing of materials, ceramics in particular. Fundamental properties such as crystallinity, composition, crystal phase, phase mixing, domain structure, grains and grain boundaries, as well as porosity will be covered. The main methods used to control these properties in order to develop and improve materials for specific applications will be addressed. Processes such as calcination, sintering, annealing, plasma treatments, mechanical working, crystallisation and dopant addition will be addressed. A discussion will be made on the influence of these processes on specific ceramic systems using phase diagrams. Specific techniques for preparation of bulk and thinner components, including sol-gel method, casting, extrusion, physical and chemical vapor deposition, screen printing or tape casting will be discussed. The role of various aspects of materials processing and their influence on the material and its integration in practical devices will be addressed.

Learning and teaching methods of delivery:	**Weekly contact**: 2 - 3 lectures per week over 9 - 10 weeks (within Weeks 1-11) and 2 - 3 tutorials in total.
Assessment pattern:	2-hour Written Examination = 100%
Re-assessment pattern:	Oral Re-assessment = 100%
Module coordinator:	Prof J T S Irvine
Module teaching staff:	Prof J T S Irvine, Dr C Savaniu

CH5517 Advanced Physical Inorganic Chemistry

SCOTCAT Credits:	10	SCQF Level 11	**Semester**	2
Academic year:	2018/9			
Planned timetable:	To be arranged.			

This module involves distinct sections on photophysics of coordination complexes including theory and applications, and inorganic 'open shell' compounds including synthesis, characterisation and applications of paramagnetic inorganic species.

Learning and teaching methods of delivery:	**Weekly contact**: 2 - 3 lectures per week over 9 - 10 weeks (within Weeks 1-11) and 2 - 3 tutorials in total.
Assessment pattern:	2-hour Written Examination = 100%
Re-assessment pattern:	Oral Re-assessment = 100%
Module coordinator:	Dr E Zysman-Colman
Module teaching staff:	Dr E Zysman-Colman, Dr B Bode

CH5518 Blockbuster Solids

SCOTCAT Credits:	10	SCQF Level 11	**Semester**	2
Academic year:	2018/9			
Planned timetable:	To be arranged.			

This module covers two major topics. The first deals with modern materials which have a major impact on our lives, focusing on how the material's structure influences its electrical, magnetic and thermal properties. In the second section, emphasis will be placed on metal organic frameworks and how they can be used for the storage and release of gases.

Learning and teaching methods of delivery:	**Weekly contact**: 2 - 3 lectures per week over 9 - 10 weeks (within Weeks 1-11) and 2 - 3 tutorials in total.
Assessment pattern:	2-hour Written Examination = 100%
Re-assessment pattern:	Oral Re-assessment = 100%
Module coordinator:	Prof P Lightfoot
Module teaching staff:	Prof P Lightfoot, Prof R E Morris