Master of Science Geochemistry

Programme Requirements

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: CH5715, CH5517 - CH5518 **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 - Semester 1:

ES3008 Geochemistry				
SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	1
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.				
Programme module type:	Normally compulsory for Geochemistry Postgraduate Programmes (in some circumstances ES3011 may be substituted). Optional for MSc in Oil and Gas Innovation			
Learning and teaching methods and delivery:	**Weekly contact**: 17 lectures, 15 hours of laboratory classes, 2 or more field classes over the semester.			
Assessment pattern:	2-hour Written Examination = 50%, Coursework = 50%			
Module coordinator:	Dr N Allison			
Module teaching staff:	Dr N Allison, Prof A Finch, Dr J Rae, Dr P Savage			

ES4031 Analytical Sciences

SCOTCAT Credits:	5	SCQF Level 10	**Semester:**	1
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.				
Programme module type:	Normally core for MSc Geochemsitry.			
Co-requisite(s):	CH3721 for MSc Geochemistry students			
Learning and teaching methods and 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%			
Module coordinator:	Dr R Wilson			
Module teaching staff:	Earth and Environmental Sciences staff			

ES5005 Isotope Geochemistry: Theory, Techniques, and Applications

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
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 learn how isotope measurements are made, with an introduction to mass spectrometry methods, techniques, and analysis. The latter half of the course will be devoted to 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.				
Programme module type:	Compulsory for MSc in Geochemistry Optional for MSc in Oil and Gas Innovation			
Learning and teaching methods and delivery:	**Weekly contact**: 2-hour lectures (x 10 weeks), 3-hour practical sessions (x 3 weeks)			
Assessment pattern:	2-hour Practical (Open Book) Examination = 50%, Coursework = 50%			
Module coordinator:	Dr A Burke			
Module teaching staff:	Dr A Burke, Dr P Savage			

CH3721 Physical Chemistry Laboratory				
SCOTCAT Credits:	10	SCQF Level 9	**Semester:**	1
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.				
Programme module type:	Compulsory for MSc in Geochemistry (unless BSc Chemistry is already held) Optional for Chemical Science MSc			
Learning and teaching methods and delivery:	**Weekly contact**: Daily 4-hour morning practical classes over 4 weeks (Weeks 7 - 10).			
Assessment pattern:	Coursework = 100%			
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			

Compulsory modules - Semester 2:

ES5010 Advanced Geochemistry				
SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	2
Planned timetable:	To be arranged.			
Many of the environmental challenges facing society revolve around the cycling of natural materials between fluid and solid phases. Some of the most fundamental aspects of Earth System development are investigated through geochemical methodologies that characterise and interrogate processes operating at the interface between the solid Earth and the fluid Earth. Further, the processes that concentrate many natural resources are a result of fluid-solid interactions that can be studied using organic and aqueous geochemistry. This module focuses on training in the state-of-the art techniques and methodologies that are tools that can be applied widely to address questions about environmental changes and chemistry in sediments and natural waters and, as well as utilisation and exploitation of hydrocarbon resources and Earth System evolution through time.				
Programme module type:	Compulsory for MSc in Geochemistry Optional for Oil and Gas Innovation			
Learning and teaching methods and delivery:	**Weekly contact**: 1-hour lecture (x 10 weeks) 5 x 3-hour practical sessions and 1 x 8-hour session of project presentations over the semester.			
Assessment pattern:	Coursework = 100%			
Module coordinator:	Dr E Stüeken			
Module teaching staff:	Prof D Mark and Dr T Raub			

ES5050 Earth's Greatest Hits

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	2
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.

Programme module type:	Compulsory for MSc in Geochemistry
Learning and teaching methods and delivery:	**Weekly contact**: 7 hours of lectures and 21 hours of seminars over the semester.
Assessment pattern:	Coursework (10% participation in discussion groups; 60% oral presentations; 30% review paper) = 100%
Module coordinator:	Dr J Rae
Module teaching staff:	Earth & Environmental Sciences academic and research staff

ES5051 Geochemistry Field Excursion

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	2
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. These will be analysed using the laboratory facilities available in the Department of Earth and Environmental Sciences and a scientific report will be written based on the methods used and results generated. The costs associated with this module are partially supported by the Department.

Programme module type:	Compulsory for MSc in Geochemistry
Learning and teaching methods and delivery:	**Weekly contact**: 2-hour lectures/seminars (x 5 weeks) 40-hour field trip, 4 hours of introductory sessions
Assessment pattern:	Coursework = 100%
Module coordinator:	Dr M Claire
Module teaching staff:	Dr M Claire, Dr J Cloutier, Dr A Zerkle

Optional modules - Semester 1:

ES5011 Water in the Environment

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Planned timetable:	To be arranged.			
The ability of current and future generations to understand, and predict water quality and quantity requires a solid understanding of the hydrological cycling of water, the interactions between surface and ground water reservoirs, the transport of dissolved components and water quality remediation methods. This module provides the theoretical background to surface and subsurface fluid flow and to the geochemical reactions occurring between water, soils, and sediments. Pollutant transport, bioavailaibility of elements, toxicity and metal and radionuclide transport will be covered within the aqueous geochemistry part of the module. This module provides a combination of the underpinning theory (fluid flow and contaminant transport) with the applied analytical tools required to better understand and ameliorate problems of water in the environment. The module assessment will include numerical modelling of a real contaminated groundwater system.				
Programme module type:	Optional for MSc in Geochemistry			
Pre-requisite(s):	Relevant background in chemistry			
Learning and teaching methods and delivery:	**Weekly contact**: 20 hours of lectures, 6 hours of laboratory work and 4 hours of tutorials over the semester.			
Assessment pattern:	2-hour Written Examination = 40%, Coursework (including Technical Brief, Media Interview and Qualitative analysis exercise) = 60%			
Module coordinator:	Dr N Allison			
Module teaching staff:	Dr N Allison			

ES5013 Advanced Petrogenesis

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Planned timetable:	10.00 am Mon and Tue (lectures). 10.00 - 1.00 pm Wed or Fri (practicals)			
The Earth's crust is largely created by acid and basic magmatism and many of the planet's critical resources are formed from igneous processes. The module explores the nature of that magmatism, the petrography and geochemistry of the minerals and rocks created, and the petrogenesis and evolution of the magma. The petrological characteristics of the continental crust and of the upper mantle, the principal sources of acid and basic magmas, are examined in detail for the influence which these have on the magmas created by partial melting. The economic significance of alkaline rocks as the hosts for many of the world's critical metals is considered.				
Programme module type:	Compulsory for MSc in Mineral Resources Optional for MSc in Geochemistry			
Learning and teaching methods and 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%			
Module coordinator:	Prof A Finch			
Module teaching staff:	Prof A Finch and Dr S Mikhail			

ES5300 Magmatic-related Ore Deposits

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
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.

Programme module type:	Compulsory for MSc in Mineral Resources Optional for MSc in Geochemistry
Anti-requisite(s):	ES5006
Learning and teaching methods and 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 = 25%, Coursework = 25%
Module coordinator:	Dr J Cloutier
Module teaching staff:	Dr J Cloutier and Prof A Finch

ES5301 Mineral Exploration

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
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.

Programme module type:	Compulsory for MSc in Mineral Resources
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures (x 10 weeks), 1 practical (x 2 weeks), 1 fieldtrip (x 1 week)
Assessment pattern:	2-hour Practical Examination = 50%, Coursework = 50%
Module coordinator:	Dr J Cloutier
Module teaching staff:	Dr J Cloutier, Dr R Bates

CH5511 Homogeneous Catalysis

SCOTCAT Credits:	10	SCQF Level 11	**Semester:**	1
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.				
Programme module type:	Compulsory for MSc in Catalysis Optional for MSc in Chemical Science and Chemistry MPhil. Optional for MSc in Geochemistry.			
Learning and teaching methods and 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%			
Module coordinator:	TBC			
Module teaching staff:	Prof R P Tooze, Prof D Cole-Hamilton			

CH5716 Processing of Materials

SCOTCAT Credits:	10	SCQF Level 11	**Semester:**	1
Planned timetable:	To be arranged.			
This module focuses on the processing of materials. Fundamental materials properties such as crystallinity, composition, crystal phase, phase mixing, domain structure, grains and grain boundaries, porosity and pore structure will be covered and the main methods used to control these properties in order to develop and improve materials for specific applications will be addressed. Processes including casting, extrusion, physical and chemical vapour deposition, calcination, sintering, annealing, plasma treatments, mechanical working, crystallisation and dopant addition will be described and explained. Applications in high-value metals, ceramics and semiconductor materials will be emphasised.				
Programme module type:	Optional for MSc in Catalysis Optional for MSc in Chemical Science and Chemistry MPhil Optional for MSc in Geochemistry			
Learning and teaching methods and 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%			
Module coordinator:	Prof J T S Irvine			
Module teaching staff:	Prof J T S Irvine, Dr M Cassidy			

Optional modules - Semester 2:

ES5012 Biogeochemistry

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	2
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.				
Programme module type:	Optional for MSc in Geochemistry and MSc in Oil and Gas Innovation			
Pre-requisite(s):	Normally ES3008			
Learning and teaching methods and 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%			
Module coordinator:	Dr A Zerkle			
Module teaching staff:	Dr A Zerkle, Dr M Claire, Dr S Mikhail			

ES5302 Hydrothermal Ore Deposits

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	2
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.				
Programme module type:	Compulsory for MSc in Mineral Resources Optional for Geochemistry			
Learning and teaching methods and 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%			
Module coordinator:	Dr J Cloutier			
Module teaching staff:	Dr J Cloutier			

CH5517 Advanced Physical Inorganic Chemistry

SCOTCAT Credits:	10	SCQF Level 11	**Semester:**	2
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.				
Programme module type:	Optional for MSc in Catalysis Optional for MSc in Chemical Science and Chemistry MPhil Optional for MSc in Geochemistry			
Learning and teaching methods and 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%			
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
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.				
Programme module type:	Optional for MSc in Catalysis Optional for MSc in Chemical Science and Chemistry MPhil Optional for MSc in Geochemistry			
Learning and teaching methods and 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%			
Module coordinator:	Prof P Lightfoot			
Module teaching staff:	Prof P Lightfoot, Prof R E Morris			

CH5715 Energy Conversion and Storage				
SCOTCAT Credits:	10	SCQF Level 11	**Semester:**	2
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.				
Programme module type:	Optional for MSc in Catalysis Optional for MSc in Chemical Science and Chemistry MPhil Optional for MSc in Geochemistry			
Anti-requisite(s):	CH4712			
Learning and teaching methods and 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%			
Module coordinator:	Dr R T Baker			
Module teaching staff:	Dr R T Baker, Prof J T S Irvine			

Compulsory module - Summer:

ES5099 Research Project				
SCOTCAT Credits:	60	SCQF Level 11	**Semester:**	Summer
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.				
Programme module type:	Compulsory for MSc in Geochemistry and MSc in Mineral Resources			
Learning and teaching methods and delivery:	**Weekly contact**: introductory lectures, presentations and superviosry meetings.			
Assessment pattern:	Coursework (10,000 word dissertation + other elements) = 100%			
Module coordinator:	Dr P Savage and Dr J Cloutier			