

**CHEMISTRY****General Major**

## I. Depth and Breadth of Knowledge

A, B, C. *Through a broad liberal arts and science curriculum, a student will demonstrate an understanding of how the discipline of chemistry – and science in general – is situated within the contours of Western culture, both historically and currently, and how Christians have engaged these aspects of Western culture.*

By the end of the program, a successful student will be able to...

- describe the emergence of the discipline of chemistry within the broader historical
- developments associated with the Scientific and Industrial Revolutions
- discuss how the discipline of chemistry – and science in general – has been shaped by historical forces, philosophical ideas and systems, and of religious commitments that have shaped Western culture
- provide examples of how advances in chemistry and related technologies have contributed to historical events and how they are presently shaping modern society
- connect knowledge of chemistry to the broader range of scientific knowledge and place scientific understanding in a human context that acknowledges the impact chemistry has on society and creation for both good and bad, particularly in the contexts of environmental issues, human health, and the various products that modern chemistry has produced
- outline how Christian thinkers through the centuries have engaged the complex interactions between science and religion
- articulate his or her own understanding of how their Christian faith commitment and scientific knowledge intersect with and complement one another

D. *A student will demonstrate a general knowledge of the following key concepts, methodologies, theoretical approaches, and assumptions in the discipline of chemistry :*

- the building blocks of matter
- states of matter
- chemical reactions
- the chemistry of water and aqueous solutions
- energy changes of chemical reactions
- atomic theory
- chemical bonding
- chemical equilibrium
- acids and bases
- solubility
- thermodynamics of chemical change
- chemical kinetics
- oxidation-reduction reactions and electrochemistry
- organic molecules and biomolecules
- performing chemistry experiments in the laboratory

E. *A student will demonstrate a broad understanding of the following major fields within the discipline of chemistry – in both theory and practice – and an awareness of the interdisciplinary connections between these areas of study*

- *Organic chemistry*
- *Inorganic chemistry*

- Analytical Chemistry
- Biochemistry

F. A student will demonstrate some detailed knowledge in at least four of the following fields of chemistry and the ability to do research or creative work in a field as evidence of understanding its chief contours.

G. A student will demonstrate an ability to gather, review, evaluate, and interpret information relevant to one or more of the major fields of a discipline

By the end of the program, a successful student will be able to...

- independently investigate topics in various fields of chemistry in greater detail than what is taught by the instructor and present the results of their research in written or oral form
- incorporate relevant information from literature into the planning, interpretation, and presentation of a scientific research project within one or more of the fields of chemistry

H. A student will demonstrate some creative and imaginative approaches showing critical thinking, analytical and technical skills inside and outside the discipline

By the end of the program, a successful student will...

- contribute to a collaborative semester-long project-based learning research project
- investigating a local environmental issue
- research, plan, carry out, and present results of a multi-week independent experimental research project in analytical chemistry
- research, plan, carry out, and present results of a multi-step organic synthesis

## II. Knowledge of Methodologies

A,B: A student will demonstrate an understanding of the methods of inquiry in chemistry – and science in general – that enables them to begin to discern what are the philosophical and worldview assumptions imbedded in the paradigms and conceptual frameworks commonly relied on in science and enables them to begin to judge what are the valid insights in such paradigms and concepts and evaluate how they can be used within a Christian frame of reference.

By the end of the program, a successful student will be able to....

- explain that scientists operate within a conceptual framework of reductionism as they investigate the natural world
- articulate that, as a Christian scientist, methodological reductionism is a useful framework for investigating the natural world while maintaining that reality cannot be reduced only to matter
- explain that scientists operate with the assumption that the physical world is ordered and reliable and that the laws of physics apply at all times and in all places
- articulate that the above assumption is of fundamental importance for scientific investigation, while leaving room for the possibility of God's supernatural action in the world discern in what ways knowledge of chemistry and the ability to create new forms of matter can be used either for selfish human ambition or in the service of alleviating human suffering and reducing our impact on creation

C. A student will demonstrate an understanding of and proficiency with the methods of inquiry in chemistry that enables them to investigate and solve problems in chemistry

By the end of the program, a successful student will be able to...

- conceptualize, operate at, and move between the macroscopic (observational), microscopic (models of the molecular "world"), and symbolic (the "language" of chemistry) levels of

- understanding of chemistry
- carry out and interpret results of experiments that measure the physical properties of materials and macroscopic changes of materials
- plan and perform chemical synthesis procedures that transform matter from one form to another
- employ various techniques to purify or isolate a substance from a mixture
- collect and/or interpret spectroscopic data (UV/vis, IR, NMR, MS) to characterize the structures of molecules and materials
- design, perform, and interpret analytical experiments that seek to quantify the amounts of substances
- operate and calibrate the instruments that are used for quantitative chemical analysis (UV/vis, AA, ISEs)
- perform chromatography experiments to separate components of mixtures (preparative chromatography) and quantify the amounts of components in a mixture (GC, HPLC)
- express scientific ideas mathematically and use mathematics to model scientific knowledge and quantify experimental observations
- employ computers to visualize and calculate the properties of molecules and molecular systems and use spreadsheet programs to manage data, perform calculations, and create tables and figures

### III. Application of Knowledge

A. *A student will demonstrate the ability to review, present, and interpret information and experimental data to develop lines of argument and make sound judgments that respect the data that are being studied and employ appropriate and responsible paradigms.*

By the end of the program, a successful student will be able to...

- apply their understanding of the theories, models, concepts, and tools of chemistry to explaining and predicting processes and structures involving molecules and molecular systems
- employ knowledge of molecular structures to explain and predict the function and reactivity of molecules, materials, and biomolecules
- interpret experimental data collected in a laboratory and develop lines of arguments and draw conclusions that are supported by such experimental data

B. *A student will demonstrate the ability to use a basic range of appropriate techniques to analyze information, evaluate the appropriateness of different approaches to solving problems, and propose solutions to chemical questions and problems.*

By the end of the program, a successful student will be able to...

- identify suitable problems or issues to investigate and construct good questions or hypotheses that can be researched or tested
- design, perform, and interpret experiments in various fields of chemistry that seek to answer questions about the chemical aspects of matter
- identify the appropriate chemistry procedure or instrument that will most effectively allow them to investigate a question or hypothesis
- propose the most appropriate theory or solution that answers a research question
- reflect on an experiment and identify sources of error and uncertainty and propose improvements to an experiment
- make appropriate approximations and evaluate the reasonableness of a solution to a problem

- perform statistical analyses of data and express the uncertainty of experimental data

*C. A student will demonstrate the ability to make use of scholarly reviews and primary sources with abeginning sense of critical judgment of the value of the sources.*

By the end of the program, a successful student will be able to...

- search for and locate relevant reviews or journal articles on chemistry topics
- read, understand, and critique scientific literature pertaining to chemistry topics
- incorporate scientific literature into lab reports
- employ scientific literature in the planning, interpretation, and communication of a research project

#### IV. Communication Skills

*A student will demonstrate the ability to communicate reliably, and winsomely and with conviction –orally and in writing – to a range of audiences*

By the end of the program, a successful student will be able to...

- clearly communicate on written assignments their steps and logic in solving problems, using correct significant figures, units, and chemical drawings as required
- orally communicate thoughts, insights, questions, and arguments in small team settings and in full class discussions
- take careful notes of experimental procedures and observations in a laboratory notebook prepare tables, figures, and graphs – and their accompanying legends and captions – that clearly and concisely communicate scientific results
- write a scientific report about an experiment that they carried out that provides sufficient context and background information, a clear description of experimental methods, logical and clear presentation of experimental results, thoughtful interpretation and discussion of results, proper referencing, and a concise summary
- write a research paper about a special topic in chemistry
- prepare and deliver an oral presentation (with appropriate visual aids) about a scientific experiment or research project that they have carried out or a special topic that they have researched
- perform a chemical demonstration and explain the concepts associated with it to a group of peers
- provide constructive criticism of written reports or oral presentations made by peers
- explain chemical and scientific aspects of current issues to non-specialists

#### V. Awareness of the Limits of Knowledge

*A student will demonstrate an awareness of the limits of their own knowledge and that of other humans, knowing that we see now as “through a glass darkly”, balanced by a recognition of patterns of constant standards rooted in the created order that have always reassured men and woman that truth, right, and wrong can be discerned.*

By the end of the program, a successful student will be able to...

- articulate that chemistry – and science in general – is only one of many ways of knowing and investigating the world around us
- maintain a sense of humility in the face of the limitations of human understanding of God and nature describe how scientific knowledge and practice change
- identify the limitations of the models that chemists use to explain data, and communicate theories and ideas

- explain that the products of chemistry may have unintended negative consequences for human health and the environment

VI. Maturity and Professional Capacity

*A. A student will demonstrate qualities and transferable skills necessary for further study, employment and community involvement in church and society, requiring the exercise of personal responsibility and decision-making in the context of membership in Christ's church and as part of God's world and working effectively with others.*

By the end of the program, a successful student will be able to...

- work effectively with others in various situations, including a laboratory setting, classroom setting, or on a team research project
- act with integrity and honesty as they perform scientific experiments, record and report their results, and interact with people more generally
- operate in a chemistry laboratory with due consideration to safety of themselves and others
- employ chemical intuition, knowledge, and problem solving skills to make contributions to solving chemical problems encountered in new situations
- act in a professional manner
- explain chemical and scientific aspects of current issues to community members who are non-specialists
- demonstrate to Christians and non-Christians that faith and science are not at odds with one another and can provide a complementary and more unified understanding of reality

*B. A student will demonstrate the ability to identify and address their own changing needs in a changing world and to select, in community, an appropriate program for further study*

By the end of the program, a successful student will be able to...

- evaluate their own suitability for the various vocations that involve a background in chemistry
- articulate their own goals for what career path they like to take
- connect with practitioners, alumni, faculty, and trusted friends and family to discuss opportunities that exist for students with chemistry training

*C. A student will demonstrate behaviour consistent with academic integrity and the ethic of educated Christians, committed to using their learning in service to neighbour and to the glory of God.*

By the end of the program, a successful student will be able to...

- act with integrity in their scientific endeavours and in all areas of life
- celebrate and communicate the beauty of chemistry as a human activity of discovering, creating, and transforming the world around us that God has created
- appreciate the power of chemistry – for good and bad – at work in lives and the world around us, so that they may use their knowledge and skills in responsible ways that bring healing and restoration

**Minor**

By the end of the program, a successful student will be able to...

I. Depth and Breadth of Knowledge

- connect knowledge of chemistry to the broader range of scientific knowledge and place scientific understanding in a human context that acknowledges the impact chemistry has on society and creation for both good and bad, particularly in the contexts of environmental issues, human health, and the various products that modern chemistry has produced

- demonstrate a general knowledge of the following key concepts, methodologies, theoretical approaches, and assumptions in the discipline of chemistry
    - the building blocks of matter
    - states of matter
    - chemical reactions
    - the chemistry of water and aqueous solutions
    - energy changes of chemical reactions
    - atomic theory
    - chemical bonding
    - chemical equilibrium
    - acids and bases
    - solubility
    - thermodynamics of chemical change
    - chemical kinetics
    - oxidation-reduction reactions and electrochemistry
    - organic molecules and biomolecules
    - performing chemistry experiments in the laboratory
  - demonstrate a broad understanding of a few of the following major fields within the discipline of
  - chemistry – both in theory and in practice – and an awareness of the
  - interdisciplinary connection between these areas of study:
    - Organic Chemistry
    - Inorganic Chemistry
    - Analytical Chemistry
    - Biochemistry
    - Environmental Chemistry
    - Thermodynamics
  - independently investigate a topic in a field of chemistry in greater detail than what is taught by
  - the instructor and present the results of their research in written or oral form
  - research, plan, carry out, and present results of a multi-week experimental project in a field of
  - chemistry
- II. Knowledge of Methodologies
- discern in what ways knowledge of chemistry and the ability to create new forms of matter can be used either for selfish human ambition or in the service of alleviating human suffering and reducing our impact on creation
  - demonstrate an understanding of and proficiency with the methods of inquiry in chemistry that enables them to investigate and solve problems in chemistry
  - conceptualize, operate at, and move between the macroscopic (observational), microscopic (models of the molecular “world”), and symbolic (the “language” of chemistry) levels of understanding of chemistry

III. Application of Knowledge

- apply their understanding of the theories, models, concepts, and tools of chemistry to explaining and predicting processes and structures involving molecules and molecular systems
- employ knowledge of molecular structures to explain and predict the function and reactivity of molecules, materials, and biomolecules
- interpret experimental data collected in a laboratory and develop lines of arguments and draw conclusions that are supported by such experimental data
- design, perform, and interpret experiments in various fields of chemistry that seek to answer questions about the chemical aspects of matter
- reflect on an experiment and identify sources of error and uncertainty and propose improvements to an experiment

#### IV. Communication Skills

- clearly communicate on written assignments their steps and logic in solving problems, using correct significant figures, units, and chemical drawings as required
- orally communicate thoughts, insights, questions, and arguments in small team settings and in full class discussions
- take careful notes of experimental procedures and observations in a laboratory notebook prepare tables, figures, and graphs – and their accompanying legends and captions – that clearly and concisely communicate scientific results
- write a scientific report about an experiment that they carried out that provides sufficient context and background information, a clear description of experimental methods, logical and clear presentation of experimental results, thoughtful interpretation and discussion of results, proper referencing, and a concise summary

#### V. Awareness of the Limits of Knowledge

- articulate that chemistry – and science in general – is only one of many ways of knowing and investigating the world around us
- maintain a sense of humility in the face of the limitations of human understanding of God and nature
- identify the limitations of the models that chemists use to explain data, and communicate theories and ideas
- explain that the products of chemistry may have unintended negative consequences for human health and the environment

#### VI. Maturity and Professional Capacity

- work effectively with others in various situations, including a laboratory setting, classroom setting, or on a team research project
- act with integrity and honesty as they perform scientific experiments, record and report their results, and interact with people more generally
- operate in a chemistry laboratory with due consideration to safety of themselves and others celebrate and communicate the beauty of chemistry as a human activity of discovering, creating, and transforming the world around us that God has created
- appreciate the power of chemistry – for good and bad – at work in lives and the world around us, so that they may use their knowledge and skills in responsible ways that bring healing and restoration