QUALIFICATIONSPECIFICATION							SECTION A
QUALIFICATION DEVELOPER	Botswana International University Science and Technology						
TITLE	Bachelor of Science (Honours) in Chemistry (Environmental and Analytical Chemistry)			**NCQF LEVEL**	8		
FIELD	Natural, Mathematical and Life Sciences		**SUB-FIELD**	Environmental and Analytical Chemistry			
New qualification	✓	Review of existing qualification					
SUB-FRAMEWORK	General Education		TVET		Higher Education	✓	
QUALIFICATIONTYPE	Certificate		Diploma		Bachelor		
	Bachelor Honours	✓	Master		Doctor		
CREDIT VALUE	132						

1. RATIONALE AND PURPOSE OF THE QUALIFICATION

1.1. Rationale of the Qualification

The need for specialized qualification in Environmental and Analytical Chemistry in Botswana, the region and internationally has been indicated in various reports, surveys and documents such as the Botswana National Research, Science and Technology Plan Final Report (2005). Botswana's economic development has been heavily dependent on mining and as such Botswana has undertaken research aimed at contributing to improved value addition and beneficiation of natural resources through research in areas such as (i) Research into mining bi-product utilisation, (ii) Research into Environmentally Cleaner Production Technologies and (iii) Chemical Sciences research into improved extraction and processing technologies. The provision of the Environmental and Analytical Chemistry qualification puts Botswana in a strategic position in so far as analysis of the chemicals arising from mining is concerned, their environmental impact as well as benefits that can be derived from useful by products emanating from mining activities. The Botswana Human Resources Development Council (Top Occupations in high Demand as at December 2016) released a list of occupations in demand and the list was made to align with both current and future labour market trends. The HRDC has also taken note of the fact that as the economy grows, there will be emerging skills needed especially in a knowledge based economy which is driven by science, technology, innovation, research and development. The HRDC report lists Environmental and Analytical Chemistry professions as among those in demand such as Water Chemists,

Soil Scientists, Environmental Protection Professionals, Chemical Technicians, Research Technicians and Science and Technology Researchers. In addition, the Global Competitiveness Report (2016-2017) lists Botswana at position number 107 out of 138 countries based on the 'Availability of scientists and engineers', an indication of high demand of scientists such as Environmental Analytical Chemists. Water is a scarce natural resource in Botswana, owing to the country being semi-arid (Botswana Climate Variability and Change: Understanding the Risks Draft Policy Note 2010) and this has put constraint to economic development and growth for the agricultural (irrigation) and mining sectors. As a result, future growth of these sectors will require much more emphasis on re-use of wastewater, rainwater harvesting and desalination. Environmental and Analytical Chemists will be critical in these regard in ensuring that re-use of wastewater and harvested rain water are safe for use and consumption by people and animals. In 2003, underground water provided 55.5% of the national demand for fresh water while rivers and dams provided 5.6 and 39.9% respectively. This implies that the need to use treated effluent (or 'new' water) should be escalated so as to meet the water supply demand in Botswana. The Environmental and analytical chemistry profession is also described as of short supply at medium level (DRST 2009). According to the report, environmental and analytical chemistry professionals are required in the mining, energy, agriculture, environmental affairs, pollution control and health sectors. Chemical Technicians are also in short supply in the education sector. Analytical chemists and environmental chemists, are among the 42 professional categories enjoying scarce skill allowance in the civil service owing to their scarcity in Botswana. Analytical and environmental chemists, including chemistry teachers enjoy the highest scarce skill allowance of 40% to basic salary and are categorized in the same bracket as medical doctors, dentists, engineers, architects, quantity surveyors, pharmacists. Laboratory analytical chemists are also categorized as a profession with acute scarcity (Tsa Badiri Consultancy 2015). Most of researchers in Botswana hold Bachelors/Masters degrees as opposed to Doctorate degrees (DRST 2009). There is therefore need to upgrade Analytical and Environmental Chemistry researchers to Honours, Masters and PhD levels. During the National Development Plan (NDP) 11 the Botswana Government will continue to grow the economy through beneficiation of minerals, various agricultural products and indigenous products / herbs. The proposed Qualification will help to diversify the economy as there is potential for growth in the manufacturing industry. Botswana as a cattle country has potential for vibrant soap and leather industries. In addition to this, Botswana has the potential to develop IV fluids and drugs. Botswana can also convert its huge supply of coal into high value petroleum and chemical products. This could replace imported fuels and other chemicals. These activities require analytical chemists and environmental chemists. There is high demand environmental and analytical chemistry graduate applies regionally and internationally. The Republic of

South Africa has a high demand for Environmental analysts and analytical chemistry researchers. Other area of high demand in South Africa which relies on the Environmental and analytical chemists include Research and Development Managers, Environmental Managers, Safety, Health, Environment and Quality Practitioners, Air Pollution Analyst, Water Quality Analyst, Physical Science Teachers, Natural Science Teachers, Chemistry Technicians, Physical Science Technicians, Forensic Technicians, Food and Beverage Technicians, Manufacturing Technicians and Water Inspectors (South Africa Government Gazette 2014).

Environmental and analytical chemists are also required in the oil sector as 11 African countries have proven oil reserves (https://www.sablog.kpmg.co.za/2014/04/african-chemical-industry-hidden-opportunity/). In the United states of America, the demand for Environmental Chemists and Analytical Chemical Technicians grew by 3.1% and 4.2%, respectively in 2014 (Rovner, 2014). Environmental and Analytical Chemists are in demand in Australia (http://www.visabureau.com/australia/anzsco/jobs/chemist-jobs-australia.aspx). In Europe, shortages of Chemical Technicians are expected (C and E News, 93 issue 24, pp34-26, 2005). The proposed qualification in line with Vision 2036 as it will promote the following pillars (i) a knowledge based economy - the use of science, technology and innovation to propel economies to high levels of efficiency is key to supporting socio-economic development (ii) promote human capital development-as the country will have developed an internationally competitive workforce that is productive and has international exposure and (iii) Education and skills development-Botswana society will be knowledgeable with relevant quality education that is outcome based, with an emphasis on technical and vocational skills as well as academic competencies and (iv) Ecosystem functions and services-providing research for the identification and development of marketable products. It will also produce environmental and analytical chemists (and Chemical Technicians) for the region as well as the international community. The qualification in line with the vision of the Botswana International University of Science and Technology's vision "… To provide globally competitive and high quality science, engineering and technology academic Qualifications in order to produce employment-ready graduates through excellence in teaching, learning, research, collaborative partnerships, industry linkages and community engagement." It is also in line with the University's vision "…to be a Center of Excellence, a world-class research institution, and the Science, Engineering, and Technology University of choice in the region, and the African continent.".

1.2. Purpose of the Qualification

The purpose of the Environmental and Analytical Chemistry qualification at honours level is to:

1.2.1. To produce graduates who can develop and use specialized analytical techniques to obtain data to solve environmental problems such as pollution of the air, soil and water.

1.2.2. To produce graduates with specialized in-depth knowledge in environmental and analytical chemistry issues to address one of Botswana's domestic sustainable development goals of 'clean water and sanitation' by providing analytical methods and techniques that can address drinking water quality.

1.2.3. To produce graduates with specialized in-depth knowledge in environmental and analytical chemistry issues to help solve waste management problems in Botswana such as wastewater, domestic waste and industrial effluent to help Botswana achieve one of its domestic sustainable development goals of 'sustainable cities and waste management'.

1.2.4. To produce graduates with specialized research skills to enable them conduct applied research to address various environmental problems such as clean water, climate change, food production, desertification and environmental pollution facing the country and the world at large. The skills in analytical and environmental research open doors for graduates to partner with reputable universities or organizations to conduct research and this go a long way in helping fulfil Botswana's vision imperatives of producing domestic human capital that is integrated into global labour market.

1.2.5. To produce graduates with a qualification that will enable them to qualify for higher education and training in Environmental and Analytical Chemistry or related field in support of the life-long learning principle.

2. ENTRY REQUIREMENTS (including access and inclusion)

2.1 Bachelor's degree in Chemistry (Environmental & Analytical Chemistry) degree or its equivalent.

2.1. Applicants who do not meet the above criteria but possess relevant industry experience may be considered through Recognition of Prior Learning (RPL) and Credit Accumulation and Transfer (CAT) policies for access. This consideration will be done following guidelines of the ETP which are aligned with BQA/National policies.

3. QUALIFICATIONSPECIFICATION SECTION B

GRADUATE PROFILE (LEARNING OUTCOMES)	ASSESSMENT CRITERIA
3.1. Evaluate highly specialized and advanced environmental and analytical chemistry information.	3.1.1. Critique, analyze and modify the quality of data derived from a variety of sources which may be contradictory or divergent relating to analytical methodologies applied to solving environmental issues such as pollution and waste management.
3.2. Justify the choice of oral, written and electronic scientific standard operating procedures in environmental and analytical chemistry processes and applications.	3.2.1. Design highly specialized appropriate procedures for generating selected Environmental and Analytical Chemistry information and applied with due concern for bias and for any ethical and safety considerations. 3.2.2. Invent appropriate forms of enquiry by applying highly specialized standard procedures in Chemistry such as experimental or computational techniques or deductive reasoning. 3.2.3. Record and integrate data accurately and truthfully and in appropriate formats. 3.2.4. Critique data and scientific evidence and from such analysis valid highly specialized arguments and conclusions are presented.
3.3. Generate advanced and highly specialized key scientific reasoning skills and evidence towards application of analytical chemistry in solving problems affecting the environment.	3.3.1. Demonstrate ability to judge and justify the best analytical methodology for carrying out analysis of a particular environmental pollutant. 3.3.2. Justify and generate logical thinking in environmental sampling, sample preparation and analysis and identify naïve and flawed scientific data. 3.3.3. Critique and discriminate inductive (effect to cause or specific to general) and deductive (cause to effect or general to specific) reasoning pertaining to environmental sampling, sample handling, sample preparation and sample analysis. 3.3.4. Develop and perform hypothetico-deductive reasoning on

	environmental pollution from point source pollution. 3.3.5. Critique the cause-effect relations in the face of some level of uncertainty or gap in available analytical data or methodology corresponding to a particular environmental problem. 3.3.6. Validate upon thinking and reasoning process and demonstrate that an environmental problem has been adequately solved using analytical techniques.
3.4. Communicate highly specialized scientific understanding effectively and efficiently to an audience (range: writing, orally and using visual, symbolic and/or other forms of representation in Environmental and Analytical Chemistry)	3.4.1. Justify the choice of scientific language used to correctly produce clear and coherent written documents, which follow appropriate scientific conventions. 3.4.2. Present and justify scientific information verbally in front of others. 3.4.3. Use appropriate referencing conventions, avoiding plagiarism when writing scientific journals and reports and respecting intellectual property. 3.4.4. Correctly and appropriately use non-verbal forms of representation.
3.5. Solve complex and unpredictable scientific problems regarding environmental pollution.	3.5.1. Solve, analyze and formulate concrete and abstract environmental problems and formulate analytical methods for solving such problems in familiar and unfamiliar contexts. 3.5.2. Develop and apply knowledge of theory to particular real-world environmental pollution problem. 3.5.3. Integrate knowledge, e.g. from various disciplines or modes of enquiry in formulating analytical techniques and application to solving environmental pollution problems.
3.6. Select and apply effective Information and Communication Technology (ICT) skills to illustrate and	3.6.1. Perform tasks related to advanced computer literacy skills such as modelling and mapping of polluted sites. 3.6.2. Critically assess the validity of ICT solutions for analytical method development applied to problems posed by

describe an analytical chemistry technique towards solving an environmental problem.	environmental pollution. 3.6.3. Use ICT that is appropriate to solving environmental pollution problems, e.g., for: computational applications; simulation applications; pattern recognition; automation and control; managing large volumes of data.
3.7. Work effectively as a member of a team or group in highly specialized environmental and analytical chemistry project or investigations.	3.7.1. Provide evidence of successful and effective contributions in group work for environmental sampling, sample handling, preparation and analysis and formulation of analytical techniques for solving such environmental pollution problems. 3.7.2. Communicate the outcomes of environmental pollution remediation group work effectively and with respect for the contributions of each group member. 3.7.3. Apply organizational skills in managing group work in analytical method development and environmental pollution control.
3.8. Apply highly specialized scientific knowledge and ways of thinking to societal issues, taking into account ethical and cultural considerations.	3.8.1. Formulate analytical methodologies and pollution control strategies that are relevant to current societal issues. 3.8.2. Critically evaluate public information dealing with current state of the environment and the application of analytical methods in solving such problems. 3.8.3. Make ethically and culturally sensitive decisions on the effects of scientifically based activities on society. 3.8.4. Identify the socio-economic impact of state of environment interventions in society. 3.8.5. Apply scientific knowledge regarding application of analytical methods to solving environmental issues for the direct benefit of others, e.g. to junior students, in schools or in the community.
3.9. Design and apply appropriate analytical chemistry research methods to solve	3.9.1. Design appropriate environmental sampling, sample handling, preparation and analysis methodologies, collect accurate and relevant data and evaluate recent literature

environmental problems.	and discuss and present the results. 3.9.2. Evaluate and critique the significance of the results in context by comparing theoretical predictions on the state of the environment with published data. 3.9.3. Justify the implications of the findings on management of environmental problems under consideration. 3.9.4. Analyze and critique results of an analytical experiment or other type of research investigation and draw valid conclusions and evaluate the level of uncertainty in these results and expected outcomes. 3.9.5. Propose and justify recommendations related to the research addressing environmental pollution. 3.9.6. Select and justify analytical chemistry statistics used to manipulate precise and intricate ideas to construct logical arguments. 3.9.7. Engage and critique current research practices and techniques related to environmental pollution and the application of analytical chemistry to mitigate environmental problems.
3.10. Undertake a highly specialized research project in applying and formulating analytical techniques to solving environmental pollution problems and waste management issues	3.10.1. Perform scientific experiments on development of analytical technologies for solving environmental issues such as pollution, climate change and treatment of waste for re-use or other types of research investigation which produce meaningful results. 3.10.2. Undertake appropriate analysis of the data and compile results in terms of published scientific literature and present them in the form of a written dissertation.

4. QUALIFICATIONSTRUCTURE SECTION C			
FUNDAMENTAL COMPONENT Subjects / Units / Modules /Courses	**Title**	**Level**	**Credits**
CORE COMPONENT Subjects / Units / Modules /Courses	Host Guest Chemistry	8	24
	Extraction Techniques	8	12
	Pollution Remediation Technologies	8	12
	Research Project	8	24
	Green Chemistry	8	24
	Water Chemistry	8	12
	Sensors for Environmental Analysis	8	12
	Soil Chemistry	8	12
ELECTIVE COMPONENT Subjects / Units / Modules /Courses			

Rules of combinations, Credit distribution (where applicable):

Table 1. Credit Distribution

NCQF Level	Credit Contribution
Level 8	132

Table 2. Credit Contribution for Fundamental and Core modules

Component	Credit Contribution
Core	132

5. ASSESSMENT AND MODERATION ARRANGEMENTS

ASSESSMENT ARRANGEMENTS

5.1. Formative Assessment

All formative assessments shall be aligned to learning outcomes. Formative assessment will contribute 50% towards final grade.

5.2. Summative Assessment

Summative assessment will contribute 50% of the final grade. Assessors must be BQA registered and accredited.

MODERATION ARRANGEMENTS

There will be internal and external moderation for the qualification.
Moderators must be BQA registered and accredited. Both internal and external moderation will be done in-line with institutional and national policies

6. RECOGNITION OF PRIOR LEARNING (if applicable)

Candidates may submit evidence of prior learning and current competence and/or undergo appropriate forms of RPL assessment for the award of credits towards the qualification in accordance with applicable RPL policies and relevant national-level policy and legislative framework.

7. PROGRESSION PATHWAYS (LEARNING AND EMPLOYMENT)

This qualification is designed to facilitate vertical and horizontal progression.

7.1. Horizontal Progression

Graduates may progress horizontally between qualifications if they meet the minimum requirements for admission to the target qualification. Other comparable qualifications to this qualification include:

- Bachelor of Science and Honours in Chemistry (Materials and Nano Chemistry)
- Bachelor of Science and Honours in Chemistry (Drug Discovery and Development)

7.2. Vertical progression

Graduates from this qualification may progress to level 9 qualifications such as;

- Master of Science in Chemistry (Environmental and Analytical Chemistry)
- Master of Science in Chemistry (Drug Discovery and Development)

7.3. Employment Pathways

Graduates of the qualification may find employment in a range of public and private organisations for the following posts.

- Water Chemists
- Soil Scientists
- Environmental Protection Professionals
- Science and Technology Researchers
- Environmental Managers
- Safety, Health, Environment and Quality Practitioners
- Air Pollution Analyst
- Food and Beverage Technicians
- Manufacturing Technicians
- Water Inspectors

8. QUALIFICATION AWARD AND CERTIFICATION

8.1. Qualification Award

A candidate will be awarded a qualification in Bachelor of Science Honours in Chemistry (Environmental and Analytical) upon meeting the minimum of 132 credits as prescribed in the rules of combination.

8.2. Certification

A certificate and transcript will be issued to graduates upon successful completion of the qualification.

9. REGIONAL AND INTERNATIONAL COMPARABILITY

9.1. REGIONAL COMPARABILITY

9.1.1. University of Witwatersrand, Bachelor of Science and Honours in Chemistry (South Africa), South African Qualifications Framework, (SAQF), Level 8.

- This is a one year qualification with a total of 120 credits. The entry requirements for this qualification are a Bachelor's degree in Chemistry or its equivalent. A pass in the relevant major course at this University or any other university whose programme has been approved by Senate. At least 60% average in the final undergraduate course. This qualification affords graduates the opportunity to select topics of a more specialised or applied nature that will introduce students to some of the cutting edge work being done in diverse areas including energy, catalysis, drug discovery, environmental chemistry, solid state chemistry and bioinorganic chemistry. The qualification has both course work and research component. Modules covered in this qualification include;
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    - **Analytical Chemistry** (incorporates Environmental Chemistry and a course in Problem Solving Using Analytical Techniques)
    - **Contemporary Topics in Chemistry** (incorporates five applied or specialised lecture topics in the discipline of choice)
    - **Inorganic Chemistry** (incorporates Inorganic Spectroscopy and Reaction Kinetics in Inorganic Chemistry)
    - **Organic Chemistry** (incorporates the use of Main Group Elements in Synthesis and Stereochemical Control)
    - **Physical Chemistry** (incorporates Mathematical Methods for Chemists, Quantum Effects in Chemistry and Statistical Thermodynamics)
- The proposed qualification is similar to this qualification in that graduates cover aspects of environmental chemistry under the analytical chemistry module. However, the proposed program is different in that the graduate will have highly specialized knowledge in concepts specific to applications of analytical chemistry methodologies and techniques to solving environmental problems such as pollution.

9.2. Newcastle University (Australia), Bachelor of Science with Honours in Environmental and Analytical Chemistry & Sustainable Resource Management -AQF (Australian Qualifications Framework (AQF), level 8)

- The Australian admission requires a BSc Environmental and Analytical Chemistry. In relation to our proposed qualification, a BSc degree is a pre-requisite for entry into the program. The proposed qualification is similar to the qualification in it is compared to in that the graduate will have highly specialized knowledge in concepts specific to applications of analytical chemistry methodologies and techniques to solving environmental problems such as pollution.
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9.3. UMT - University Malaysia Terengganu, Bachelor of Science in Analytical and Environmental Chemistry-QAA (Level 8)

This is another similar qualification for duration of one year and requiring Bachelor of science in Analytical and Environmental Chemistry which is equivalent to the proposed qualification requirements. Graduates of this program will have the knowledge and skills not only in the various fields of chemistry, but have special skills in analytical chemistry methods and environments and use all the latest equipment and instruments in the field. Some of that can be pursued by graduates of this program are as a researcher, chemist for product development, process development, and environmental analysis and forensics. Graduates can also venture into the field of teaching as a lecturer or teacher.

The exit outcomes of the two equivalent qualifications cover similar scope and depth and are aligned to exit-level descriptors typical to this level and type of qualification, as well as competencies required for registration and accreditation with professional bodies such as Royal Society of Chemist (RSC) and American Chemical Society (ACS). However, what sets this qualification apart from the qualifications examined is that, there is integration entrepreneurial and business attributes to the proposed qualification which equips the graduate with the requisite skills to be able to start their own businesses if they cannot find employment.

10. REVIEW PERIOD

Review period is 5 years or as and when the need arises.