QUALIFICATION SPECIFICATION SECTION A							
QUALIFICATION DEVELOPER	Botswana International University of Science and Technology						
TITLE	Bachelor of Engineering (Honours) in Chemical Engineering				NCQF LEVEL	8	
FIELD	Manufacturing, Engineering and Technology		SUB-FIELD		Engineering and Engineering Trades		
New qualification	✓		Review of existing qualification				
SUB-FRAMEWORK	General Education		TVET		Higher Education	✓	
QUALIFICATION TYPE	Certificate		Diploma		Bachelor		
	Bachelor Honours	✓	Master		Doctorate/ PhD		
CREDIT VALUE					636		

RATIONALE AND PURPOSE OF THE QUALIFICATION

RATIONALE

The qualification of Bachelor of Engineering in Chemical Engineering at Botswana International University of Science and Technology is fundamental and strategic to the development of chemical and related industries in Botswana and the region. At present, BIUST is the only tertiary institute in this country that is training Chemical Engineers in response to the critical need and shortage of chemical engineers in Botswana particularly, the SADC region and the world in general [1]. The Human Resource Development Council (HRDC) report of 2016 lists Chemical Engineers as one of the top occupations in high demand in the Manufacturing sector and also highlights the need for continuous engagement with industry to develop graduates that are ready to address the ever changing needs of industry [2]. Chemical Engineering is one of the most employable subjects in the world today and is a multi-use degree producing graduates that are able to work in other sectors such as mining, water, biotechnology, finance, energy, occupational health and safety [1,3]. Thus, this qualification is also capable of addressing skills shortages in other key areas identified by the HRDC [1]. A study in done in Europe has highlighted that there has been a decline in the number of students studying chemical engineering as a result of a lack of understanding of the content of the discipline and career prospects [4].

The qualification will be able to supply the labour market with chemical engineers with skills that are essential for industrial development and beneficiation of natural resources such as minerals, chemicals and agricultural products.

The qualification is undertaking world class quality research and teaching that is problem oriented, interdisciplinary and relevant to society that will contribute towards business development in Botswana and the region. Unlike other engineering disciplines or professionals, Botswana does not currently train its own chemical, materials and metallurgical engineers but its economic development and sustainability depends largely on these professionals. The qualification aligns with the mission of the University as it focuses on energy, water, resources and process engineering which are critical for the sustainable development of Botswana as stipulated in the University's mission and vision statement.

PURPOSE OF QUALIFICATION

The purpose of this qualification is to produce graduates with highly specialized knowledge, skills and competences to:

- Design, optimise and manage construction of processes for the production of chemicals, fuels, metals and food products.
- Identify, diagnose and solve unpredictable industrial problems encountered with process equipment and product quality in the process industry.
- Apply advanced specialist knowledge to solve environmental problems related to the sustainable use of natural resources within the chemical and process industry.
- Implement and develop safety, health, environmental and quality (SHEQ) protocols and procedures in the chemical and process industry.

ENTRY REQUIREMENTS (including access and inclusion)
• The minimum entry requirement is Certificate IV, NCQF Level 4 (Botswana General Certificate of Secondary Education, BGCSE) or its equivalent with passes in Mathematics, Physics, Chemistry and English Language • Recognition Prior Learning (RPL) and Credit Accumulation and Transfer (CAT) will be considered for entry to this qualification for applicants who do not meet the minimum entry requirement.

QUALIFICATION SPECIFICATION SECTION B	
GRADUATE PROFILE (LEARNING OUTCOMES)	**ASSESSMENT CRITERIA**
1: Apply a range of highly specialized engineering principles to systematically diagnose and solve complex chemical and process engineering problems	1.1. Interpret test results for raw materials and products to improve and optimise the process to achieve required product specification for customer satisfaction. 1.2. Use principles of mass and energy balances, mass and heat transfer in assessing and solving complex chemical and process engineering problems for sustainability and profitability. 1.3. Develop models to diagnose and solve industry related problems
2: Apply highly specialized knowledge of mathematics, natural science and engineering sciences to defined and applied chemical and process engineering procedures, processes, systems and methodologies to solve complex chemical and process engineering problems.	2.1. Integrate principles from unit operations, process control, environmental engineering and reaction engineering to achieve products meeting customer specifications. 2.2. Develop processes and/or procedures to produce materials, components and products for various industrial specifications and national development.

3: Perform procedural and non-procedural design of *complex* chemical and process components, systems, works, products or processes to meet desired needs normally within applicable standards, codes of practice and legislation.	3.1. Develop flowsheets, and pipe and instrumentation diagrams (PID) according to set standards to meet project objectives. 3.2. Perform mass and energy balance on processes for optimisation, sustainability and profitability. 3.3. Select appropriate materials, equipment and standards to meet design specifications. 3.4. Perform costing and project evaluation. 3.5. Perform safety and loss prevention using techniques such as HAZOP and process plant site selection to meet legislative requirements.
4: Conduct investigations of *complex* chemical and process problems through locating, searching and selecting relevant data from codes, databases and literature, designing and conducting experiments, analysing and interpreting results to provide valid conclusions.	4.1 Formulate research objectives, research questions and hypothesis to address industrial problem. 4.2 Search and compile relevant data using codes, databases and literature to address a specific industrial problem. 4.3 Plan and conduct plant trials addressing specific industrial problem. 4.4 Analyse results from plant trials and laboratory experiments to address specific industrial problem. 4.5 Draw conclusions from results, and 4.6 Identify limitations and make appropriate recommendations.
5: Apply advanced specialist knowledge in engineering methods, skills, tools, including Information technology	5.1 Select appropriate techniques, resources and modern engineering tools (engineering softwares) to solve industry related problems.

	5.2 Understand the constraints of using different engineering application packages when solving industry related problems. 5.3 Use appropriate packages or softwares to predict and model complex chemical and process engineering industry problems
6: Communicate professional and technical information to stake holders and the community at large	6.1 Use oral and written communication effectively with engineering audiences and stack holders. 6.2 Report results obtained from procedural work, research and design projects in a professional manner. 6.3 Explain accurately the impact of engineering activities to relevant stack holders.
7: Demonstrate advanced specialist knowledge and understanding of the impact of Chemical Engineering activities on the society, economy, industrial and physical environment, and address issues by analysis and evaluation.	7.1 Monitor industrial processes on the society and the environment. 7.2 Identify the impact of industrial processes on the society and environment. 7.3 Evaluate the environmental and socio-economic factors of Chemical and Process Engineering processes. 7.4 Use engineering and scientific tools such as environmental impact assessments and life cycle assessments to Chemical and Process Engineering processes.
8: Demonstrate advanced specialist knowledge and understanding of engineering management principles and apply these to one's own work, as a member and leader in a team and to manage projects.	8.1 Implement quality planning in project management. 8.2 Apply risk and value management in decision making. 8.3 Demonstrate good leadership (e.g. delegation and coordination) in project planning and execution.

	8.4 Work as a member of a team and/or lead a team in planning and executing individual or group project(s). 8.5 Take responsibility and accountability in the tasks/project as a team member/team leader.
9: Demonstrate mastery in being able to engage in independent and life-long learning through well-developed learning skills.	9.1 Work independently on projects to achieve a desired objective. 9.2 Show competency when executing assigned industrial tasks/activities. 9.3 Exercise autonomy, initiative and authority in planning and executing projects.
10: Apply ethical principles and commit to professional ethics, responsibilities and norms of engineering technology practice	10.1 Adhere to ethical principles and professional ethics, responsibilities and norms of engineering practice in executing projects. 10.2 Observe social responsibilities when executing project(s). 10.3 Uphold professional integrity in an impartial manner.
11: Demonstrate highly specialized knowledge and understanding of economic decision-making.	11.1 Perform cost estimation for project(s). 11.2 Implement cost optimisation in decision making process.

QUALIFICATION STRUCTURE **SECTION C**			
FOUNDATIONAL COURSES **Subjects / Units / Modules /Courses**	Title	Level	Credits
	Introduction to Technical Communication and Academic Literacy	5	6
	General Chemistry I	5	12
	Introduction to Computing	5	12
	Pre-Calculus	5	12

	Introduction to Physics I	5	12
	General Chemistry II	5	12
	Introductory Calculus	5	12
	Introductory Physics II	5	12
	Introductory statistics	5	12
FUNDAMENTAL COMPONENT Subjects / Units / Modules /Courses	Title	Level	Credits
	Engineering Graphics	5	12
	Workshop Practice	5	12
	Introduction to Engineering	5	6
	Technical and Professional Communication	5	6
	Procedural Programming	5	12
	Engineering Mathematics I	5	12
	Engineering Mechanics I (Statics)	5	12
	Material Science	6	12
	Introductory Physical Chemistry	5	12
	Fundamentals of Electrical Engineering I	6	12
	Engineering Mathematics II	5	12
	Design Methods	5	6
	Strength of Materials	6	12
CORE COMPONENT Subjects / Units / Modules /Courses	Process Engineering I	6	12
	Unit Operations I	6	12
	Research methods for Engineering and Technology	6	12
	Unit Operations II	6	12
	Process Control I	6	12
	Process Engineering II	6	12
	Engineering Mathematics III	6	12
	Thermodynamics I	6	12

	Process Control II	6	12
	Chemical Engineering Thermodynamics	6	12
	Chemical Reaction Engineering	6	12
	Process Engineering Management	6	12
	Engineering Mathematics IV	6	12
	Engineering Project Management	6	12
	Separation Processes	7	12
	Membrane Separation & Bioprocess Technology	7	12
	Plant and Equipment Design	7	12
	Particulate Systems	7	12
	Environmental Engineering	7	12
	Economics, Business & Entrepreneurship	7	12
	Industrial Training	7	36
	Reactor Design	8	12
	Process Modelling, Simulation & Optimisation	8	12
	Chemical, Materials & Metallurgical Engineering Research Project (I & II)	8	24
	Chemical, Materials & Metallurgical Engineering Design Project (I & II)	8	36
	Chemical Engineering Health & Safety	8	12
OPTIONAL COMPONENT Subjects / Units / Modules /Courses	Process Dynamics & Control	8	12
	Hydrometallurgy & Electrometallurgy	7	12
	Coal & Waste Valorization	8	12
	Advanced Environmental Engineering	8	12

RULES OF COMBINATIONS, CREDIT DISTRIBUTION (where applicable):

Minimum Credits to graduate = 636

Core credits = 372

Fundamental credits = 240

Elective/Optional credits = 24

Credits at level 5 = 204
Credits at level 6 and 7 = 312
Credits at level 8 = 120

Important:
To graduate, a student must:

ASSESSMENT AND MODERATION ARRANGEMENTS

ASSESSMENT

All assessments, formative, summative, research and others (mostly work integrated learning) leading/contributing to the award of credits or a qualification should be based on learning outcomes and/or sub-outcomes. The qualification assessments are based on the following:

Coursework/Formative/CA	Summative	Research	Others
34%	51%	9%	5%

MODERATION

For quality assurance purposes, there will be internal and external moderation as per ETP policy.

Assessors and moderators must have valid registration and accreditation with Botswana Qualifications Authority (BQA) or recognized professional body.

RECOGNITION OF PRIOR LEARNING (if applicable)

RPL and CAT will be considered for the award of this qualification.

PROGRESSION PATHWAYS (LEARNING AND EMPLOYMENT)

Vertical Pathway

Possible vertical articulations:

Masters of Engineering in Chemical Engineering

Masters of Business Administration.

Horizontal Pathway

Possible horizontal articulations:

- Postgraduate Diploma in Mechanical Engineering,
- Post Graduate Diploma in Engineering Management.

Employment Pathway

Possible employment articulations:

- Chemical engineer
- Process engineer
- Safety, health, environmental and quality (SHEQ) engineer
- Research and development (R&D) engineer
- Design engineer
- Environmental process engineer

- Product and development engineer
- Product engineer
- Project manager

QUALIFICATION AWARD AND CERTIFICATION

Minimum standards of achievement for the award of the qualification

A candidate is required to achieve the minimum stipulated total credits of 636 credits in order to be awarded a Bachelor of Engineering in Chemical Engineering. The candidate must also attain and fulfill all the rules of combination required for this qualification.

Certification

Candidates meeting prescribed requirements will be awarded the certificate in accordance with standards prescribed for the award of the qualification and applicable policies.

REGIONAL AND INTERNATIONAL COMPARABILITY

The qualification is benchmarked against a regional qualification at the University of Cape Town (South Africa) Bachelor of Science in Engineering (Chemical Engineering) and two international programmes at the University of Birmingham (UK) Bachelor of Engineering in Chemical Engineering, as well as the Bachelor of Engineering (Honours) in Chemical Engineering from the University of Queensland (Australia).

The qualifications differ in terms of duration, the one offered at the University of Cape Town (UCT) and University of Queensland (UQ) have a 4- year duration, while the University of Birmingham (UB-UK) is 3 years with an option of 4 years which includes one year of Industrial Study. The duration of this qualification is 5 years. In terms of total credits for the course, there are approximately 600 credits for the courses offered at UCT and UQ which is comparable to what is offered in this qualification (660 credits), however, the UB-UK programme has 350 credits. The minimum credits to graduate at UCT is 576 and for UQ its 560. which is within ±15% of the credits required in this qualification. However, for candidates coming in with a Certificate 5 qualification, the total credits required to graduate is 558 which is within ±5% of the credits required to graduate at UCT and UQ. The major difference with the UB-UK programme is that it focuses mainly on core chemical engineering courses and does not cover much of the basic science courses (mathematics, physics, chemistry, biology and computer science that are covered in the first two years at similar programmes at UCT, UQ and BIUST. However, this qualification covers more of the entry level basic sciences in the first year of study which are covered at High School level in the United Kingdom, Australia and South

Africa. For this qualification these modules are classified as foundational level courses and are not required for applicants with a Certificate 5 qualification, which is a typical entry level requirement at UCT and UQ.

In terms of the courses taught all the qualifications cover the core chemical engineering courses namely: Thermodynamics/physical chemistry; Fluid mechanics/transport phenomena; Unit operations; Chemical reaction engineering; Plant design; Equipment/materials; Process dynamics and control; Chemical engineering laboratory and Safety and environment. All the programmes with the exception of the one offered by UB-UK cover a significant amount of basic sciences in the first two years of study. All the programmes offer specialisation in the advanced electives in emerging and existing chemical engineering fields, however, these vary depending on institutional focus. All the qualifications require some form of approved workplace attachment as part of the qualification, however, it is only at BIUST where this is credit bearing i.e. credits contributing to the credits required in the course. The workplace attachment at UCT and UQ is part of requirements for professional accreditation, not as part of core curriculum. UB-UK offers the standard 3 year BEng with an option to do 1 year industrial training for the BEng (Chemical Engineering) with Industrial Study. This qualification provides for a semester of industrial attachment which carries 36 credits. Thus, all qualifications focus on producing graduates that are ready for work in industry.

All the qualifications also require that students complete a certain number of credits in complementary studies outside the domain of engineering e.g. sociology, languages, economics, management etc. The credits allocated to these subjects is much lower at BIUST and it is not mandatory to do a language course, as in other institutions, but the student is allowed to choose from a pool of available electives. The other institutions seems to have a very strong emphasis on international student exchange programs that promote exposure of students to other languages and culture which is not currently the case with this qualification.

REVIEW PERIOD

The review period for this qualification is 5 years.